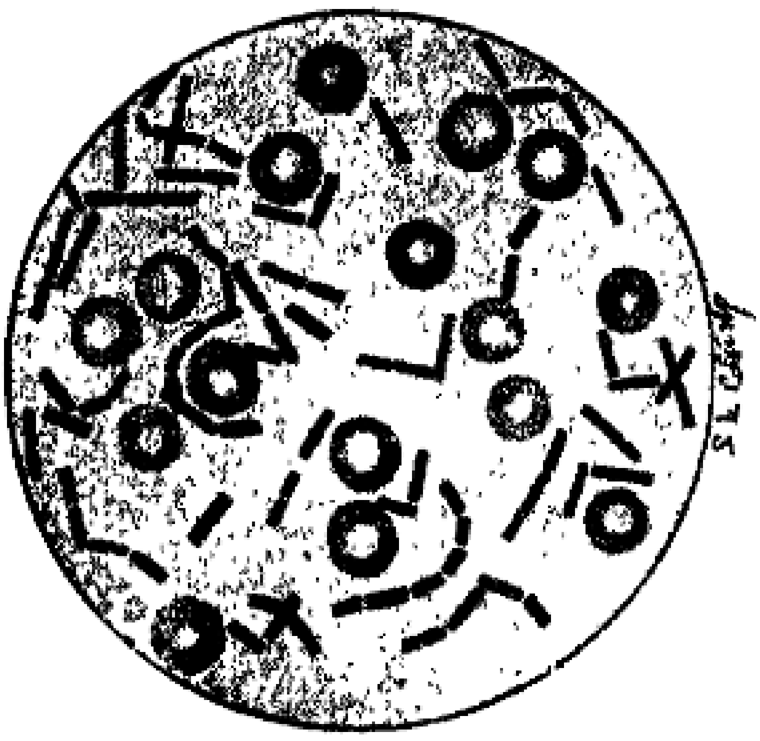
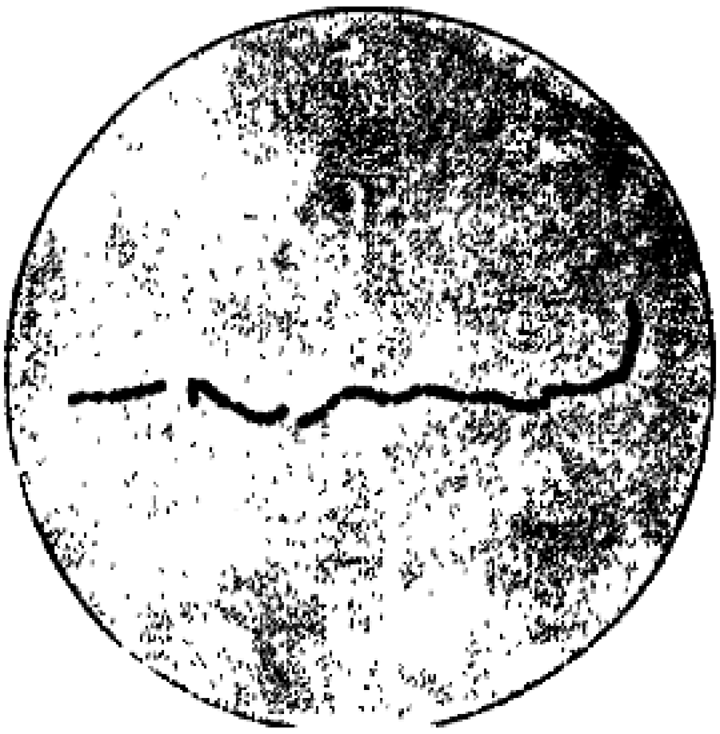
Treponema Pallidum. Stained smear (After Noguchi)



Bacillus Anthracis in blood of rabbit.



Streptococcus Pyogenes (Kolle and Wassermann)

Microscopic Slides of Germs.

A GUIDE
TO
PRACTICAL PHYSIOLOGY
AND
HYGIENE

By

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With a Foreword

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FOREWORD

I have great pleasure in writing for Dr. Gupta's little book. Books on the practical teaching of Physiology and Hygiene are unfortunately very few: and of those present, they are written mostly by teachers who themselves had no training either in the theory or the practical application of the subject or by doctors who have no experience of teaching. The present book has the great advantage that it is written by one who is not only a teacher of Physiology and Hygiene but also a busy Medical Practitioner. Dr. Gupta's treatment of the subject matter is very lucid yet brief. The value of the book is enhanced by an excellent chapter on the use of the Microscope and by several very useful blocks. I consider that the book will prove useful to the student taking up his High School Examination and the teacher alike. I wish it all the success it deserves.

M. L. Gujral.
M. B., B. S., (PUNJAB) M. R. C. P. (LOND.),
Chandni Chowk, Delhi.

Preface

Theoretical knowledge of Physiology and Hygiene is of little use to any body, least of all to a beginner, if there does not exist at the same time a proper understanding of its practical application. My object in writing this little book is to supply a want in this direction. It is believed that the book will prove helpful to candidates who are preparing for the High School Examinations of Indian Universities and Boards. Incidentally it will also be of value to the layman who feels interested in elementary Physiology and Hygiene.

My thanks are due to many teachers for their valuable help and suggestions, specially to L. Shadi Lal, Headmaster, Ramjas High School, No. 1, Delhi and Dr. M. L. Gujral, Lieut. M. B., B. S. (Punjab), M. R. C. P. (London), Chandni Chowk, Delhi.

Any suggestions from the teachers to make the book more useful, are cordially invited and would be considered to incorporate them in the next edition.

Delhi, *H. C. G.*
September, 1936.

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HUMAN SKELETON OR THE BONY FRAME WORK

I. **Articulated Skeleton:**—In articulated skeleton the various bones of which the skeleton is composed, are placed in their natural positions, and are held there by artificial joints secured with wires, nails etc.; while it should be noted that in our own bodies various bones forming various joints are held in position by ligaments, tendons and muscles. Hence our natural joints are absolutely different from the artificial joints in an articulated skeleton.

Look at such a skeleton hung before you and note the following natural divisions:—***Head, Trunk and Limbs.***

HEAD OR SKULL. Note the strong bony box which lodges the brain, called the ***Cranium***, and on its front aspect you see the various bones of the ***Face.***

TRUNK. Note the strong bony pillar the ***Spine or the Back Bone,*** on which rests the head, and is composed of many small irregular rings of bone—the ***Vertebrae.*** To the front of its upper part note a sort of bony cage —the Thorax—with some vertebrae behind, ribs on each side and breast bone in front.

LIMBS. Note that the two pairs of limbs appear to be hanging from the sides of the trunk. From the upper part of the trunk hang the ***Upper Limbs,*** and from its lower part, the ***Lower Limbs.*** The limbs are also sometimes called the ***Appendages.*** Note that the bones of the limbs are stronger, longer, and more compact than the bones of the other parts of the skeleton. Note also that the bones composing the lower limbs are much stronger and stouter than those of the upper limbs.

Sketch the skeleton as you see hanging before you and label its various parts.

N. B. MAIN USES (I) Gives support to the soft parts and thus to the whole body. (II) Gives a proper shape to the human body. (III) Protects the delicate internal organs like Brain, Heart etc. (IV) Serves for the attachment of muscles etc. and so movements are produced at the joints.

II. **Disarticulated Skeleton.** All the individual bones, forming the bony frame work of a human body comprise the ***Disarticulated Skeleton.***

Before beginning to study in detail the individual bones, we should know the different kinds of bones.

For this pick up a Shoulder-blade, a Thigh-bone, a Wrist-bone and a Vertebra. Note the marked contrast in their appearance. Hence bones are classified into:—

(*a*) ***Flat Bones*** are those in which one axis (axis of thickness) is greatly reduced out of all proportion to the other two axes (of length and breadth), so they look thin and flat e.g. Shoulder-blade.

(*b*) ***Long Bones*** are those in which one axis (axis of length) is greatly increased out of all proportion to the other two axes (of breadth and thickness), so they appear long e.g. Thigh-bone.

(*c*) ***Short or Cuboidal Bones*** are those in which all the axes are more or less equal and short, and they have got a fairly regular shape e.g. Wrist-bones.

(*d*) ***Irregular Bones*** are those which have no definite shape e.g. Vertebrae.

To which class of bones do the following bones belong?:— Sphenoid, Ulna, Hip bone, Frontal bone, Ankle bones and Phalanges.

A. **The Skull**. Pick up the skull and note that it consists of two parts—the ***Cranium*** or the ***Brain Box*** and the ***Face.***

(i) THE CRANIUM OR THE BRAIN BOX. Mark the zigzag lines of the union of the different bones forming the Cranium. These are called the ***Sutures.*** Note that the Brain Box is really a strong hollow box to lodge the brain. Sutures are formed by the firm union of the saw-like or dove-tailed edge of one bone inter-locking with a similar edge of the other bone. These are the joints in the Skull. Note that very little movement is possible in these joints.

Cranium consists of eight bones:—

(a) ***The Frontal Bone.*** It forms the forehead, also the upper part of Orbit and the roof of the nose. Note its vertical and horizontal portions. To its upper edge are united:—

(b) ***The two Parietals.*** They form a part of the roof and the sides of Cranium and unite in the middle line with each other. Note that they are quadrilateral in form and are curved like a saucer.

Distinguish the right from the left by :—

The upper edge is straight, the lower is curved and the prominence is more towards the posterior edge. See that they unite with the Frontal in front, Occipital behind and Temporal and Sphenoid bones below.

(c) ***The Occipital Bone*** forms the back of the Cranium, and the hinder part of the base of the Skull. Note its vertical and horizontal portions and also a big round hole in its horizontal part called the ***Foramen Magnum,*** and the two smooth projections around the hole called the ***Condyles*** which move on the first vertebra.

(*d*) ***The two Temporal Bones*** form the temple and complete the sides of the Cranium. Note the opening of the external ear in each. Note its flat vertical part—***Squamous part***—and its thick part projecting inwards—***Petrous part.*** Note that the external ear opening goes inwards in the Petrous part. Also note the place where the lower jaw bone unites and moves, and also the big projection of bone behind the external ear opening the ***Mastoid process.***

Distinguish the right from the left by:—external ear opening is outside, mastoid process is behind it and the flat squamous part is above.

(*e*) ***The Sphenoid Bone.*** Note that it is an irregular bone, shaped like a bat. It forms middle part of the base and a part of the sides of the Skull. It is placed in front of the horizontal part of the Occipital bone.

(*f*) ***The Ethmoid Bone.*** It is a small bone lying in front of the Sphenoid and is wedged in the horizontal part of the Frontal bone. It forms roof of the nose and front part of the base of skull, and sides of the Orbit. This bone usually gets destroyed during separation of bones. Note that its upper horizontal plate is perforated like a sieve for branches of Olfactory nerves to the nose.

N. B. **Write the names of all the bones of the Cranium and with what bones does each bone come in contact ?**

(*ii*) BONES OF THE FACE. 14 in all.

(*a*) ***The two Nasal Bones***—Small quadrilateral bones, form the bridge of nose, meet with each other in mid-line and above with the Frontal bone and below with the upper jaw bones.

(*b*) ***The two Malar, or Cheek Bones,*** also called the ***Zygomatic bones.*** Roughly quadrilateral bones and form prominences of cheeks.

(c) ***The two Superior Maxillary Bones or Upper Jaw Bones,*** are irregular bones. Each lodges the upper 8 teeth on each side. Both form the upper jaw and the front part of the roof of mouth and floor of Nasal cavity.

(d) ***Two Palatal Bones*** form the posterior part of the roof of the mouth and the floor of the nasal cavity. It is shaped like the English capital letter L.

(e) ***The two Lachrymal or Tear Bones.*** They are small thin bones situated at the inner angles of the Orbits or sockets for the eye ball. Each has got an excavation in which lodges the ***Tear Sac,*** hence the name.

(f) ***Two Spongy Bones***—Small thin twisted plate like bones, one in each nostril. It forms the lowermost prominence in each nostril.

(g) ***Vomer or Plough-share Bones.*** It is a quadrilateral thin plate of bone which forms the posterior part of the partition in the nose.

(h) ***Mandible or Lower Jaw Bone.*** It is a horse-shoe shaped bone, has sockets for 16 lower teeth in its middle curved horizontal part. The posterior vertical part is divided into two, the hinder of which forms a hinge-joint with the temporal bone. Note the movement of the lower jaw. Also note that it is the ***only bone out of the face bones which moves.*** Note in chewing the upper jaw bones do not move at all and it is only the lower jaw which moves. Sketch this bone.

Sketch the Skull as seen from (i) the top (ii) from the left side (iii) from behind (iv) from front (iv) from below; and label the various bones seen. Name the bones of which the Oribts are formed.

B. **Vertebral Column or Spinal Column or Spine or Black Bone**. Note that it is a bony pillar consisting of many single irregular pieces of bone called *Vertebrae*. This column gives the name of *Vertebrates* to those who possess it, others are called *Invertebrates*. Note that there are 4 curvatures in this column:

(*a*) Those placed in the neck—*Cervical*—7 in number, form a curve with convexity forwards.

(*b*) Those placed in the Thorax—*Thoracic* or *Dorsal* —12 in the number, form a curve with convexity backwards.

(*c*) Those placed in the Abdominal region—*Lumbar*—5 in number, with convexity forwards, and

(*d*) Those placed in the Pelvic region—*Sacral* and *Coccyx*—composed of 5 fused pieces forming Sacrum and 4 fused pieces forming Coccyx, have a curve with convexity backwards.

Count the number of Vertebrae in the column. There are 33 pieces out of which five of the Sacrum and four of the Coccyx are fused into one bone each i. e. the Sacrum Bone and the Coccyx Bone.

Select a Vertebra from the Thoracic Vertebrae viz. the sixth or seventh, and note the following points:—

(*i*) *Centrum* or *Body*. A cuboidal disc of bone forming the front part.

(*ii*) *Neural Arch*. To the back of the body is attached an arch of bone called the *Neural Arch*, enclosing a hole—the *Spinal Canal*.

(*iii*) From the arch arise two processes or projections, one on each side, called the ***Transverse Processes*** and

(*iv*) A central process behind, called the ***Spinous Process.*** Take from the vertebrae the sixth, seventh and eighth Thoracic Vertebrae and place them in position one above the other and note that the neural arches of these bones make a continuous canal through which passes the Spinal Cord in the living human being. Also note that in between the two vertebrae there is a hole on either side called ***Intervertebral Foramina*** through which the Spinal nerves pass out from the Spinal Cord.

Sketch a typical Thoracic Vertebra and label its various parts.

I. CERVICAL REGION. Next take a typical Cervical Vertebra, say the fifth and note

(*i*) The body is small and the vertebra on the whole is small.

(*ii*) Neural arch is very wide.

(*iii*) Transverse processes are short and ***there are holes in them for the passage of an artery in the living body in all cervical vertebrae.***

(*iv*) Spinous Process is short and bifid or forked.

Sketch it and show the special points.

Note the atypical vertebrae in this region and draw each.

1. ATLAS OR 1st CERVICAL.

(*a*) It has ***no body*** and no Spinous process or a very rudimentary Spinous process.

(*b*) It has two cup-shaped, polished areas—***Facets***—on its upper surface for the movement of the skull.

(*c*) It has a smooth surface—***Facet***—on the internal surface of its front part which revolves round the 2nd Vertebra.

(*d*) It has got the ***shape of a ring.***

2. AXIS OR 2nd CERVICAL.

(*a*) It has got a ***peg-like process above its body*** which is called ***Odontoid Process*** round which the atlas moves.

(*b*) On the front surface of the Odontoid process there is a small facet.

3. 7th CERVICAL OR VETEBRA PROMINENS.

(*a*) It is so called because it has a very long spinous process which can be easily felt projecting under the skin in a living body, hence a useful point in counting vertebrae.

(*b*) Sometimes its transverse processes are abnormally large simulating the ribs.

II. DORSAL OR THORACIC REGION. Select a vertebra of this region and note the special points :—

(*i*) There are ***Articular Facets on the sides of the bodies*** of these vertebrae for articulation with the heads of ribs.

(*ii*) There are similar ***Facets on of the tra nsverse processes*** for articulation with the tubercles of the ribs, with the exception of 11th and 12th Thoracic Vertebrae which have no facets on the transverse processes, as there are no tubercles on the 11th and 12th ribs. (See description of Ribs.)

(*iii*) Spinous processes are long, thin, and point downwards.

N.B. **There are 12 Thoracic Vertebrae and 12 pairs of ribs, i. e. one pair of ribs for articulation with one vertebra.**

Draw a Thoracic Vertebra.

III LUMBAR REGION. Note the following points :—

(*i*) The bodies are very large.

(*ii*) Transverse processes are very long.

(*iii*, Spinous processes are short, straight and thick, and are axe-shaped.

(*iv*) Absence of facets on the sides of the bodies and the transverse processes.

Draw a Lumbar Vertebra.

IV SACRAL REGION. The five vertebrae of this region are fused together to form one Sacral bone. Sketch it and note that :—

(*i*) It is a solid triangle with base upward and vertex below, and is fixed in between the 2 hip-bones like a wedge.

(*ii*) Its front aspect is smooth and concave, and its back aspect is rough and convex. Its posterior wall is also deficient below.

(*iii*) On either side of the middle line there are four holes for the Spinal Nerves.

(*iv*) Note the ear-shaped articular surface for articulation with the hip bones on the upper part of each of its sides.

Make a sketch of the Sacrum.

V COCCYGEAL REGION. Four small vertebrae are fused to form a small Coccyx Bone. This is also called the Tail-bone of man. In monkeys and other animals the number of vertebrae in the tail region is very large and they are not fused.

Sketch it.

C. Ribs or Costae. Note in the articulated skeleton before you that the ribs are thin, flat, curved, bony loops, 12 on each side, forming walls of Thoracic Cavity. Note that behind they are united to the

Dorsal vertebrae at two places, viz., (*i*) by their heads to the sides of the Dorsal Vertebrae and (*ii*) by their tubercles to the transverse processes.

N. B. Note that the 11th and 12th ribs have no tubercles, and so do not articulate with the transverse processes.

Note that in front, each of the upper 7 pairs of ribs is joined to the breast bone (Sternum) ***directly*** by a small cartilage called ***Costal Cartilage***; next 3 pairs are joined to the sternum ***indirectly*** by the costal cartilage of the lower rib joining to the costal cartilage of the upper rib i. e. that of the 10th to the Costal Cartilage of the 9th; that of the 9th to that of the 8th, and that of the 8th to that of the 7th, which joins directly to the Sternum. Hence 8th, 9th, and 10th ribs unite indirectly to the Sternum. Last two pairs i. e. 11th and 12th, do not unite at all to the Sternum, hence called the ***Floating or Free Ribs.*** The first 7 pairs are called ***TrueRibs.*** The last five pairs are called ***False Ribs,*** out of which last two pairs are also called ***Free or Floating Ribs.***

Note that the ribs are not placed horizontally but are inclined downwards and forwards, and their surfaces do not look forwards and backwards, but look forwards and downwards, and upwards and backwards, i. e. in their front parts the anterior surfaces look forwards and downwards, and posterior surfaces look backwards and upwards.

N. B. This doubly oblique direction of ribs plays a very important part in the act of breathing

Draw a typical rib e. g. 7th, and label the following parts:—

(*i*) ***Head,*** the posterior end, (*ii*) ***Neck,*** a narrow part beyond head, (*iii*) ***Tubercle,*** a projection beyond neck, (*iv*) ***Body or Shaft,*** the curved part beyond

Tubercle and (v) ***Sternal End***, the anterior extremity, which unites with costal cartilage.

D. Sternum or Breast Bone. Draw the breast bone and note that it has two parts :—

(i) Upper smaller part, more or less quadrilateral, broad above and narrow below, called ***Manubrium Sterni*** i. e. ***Head of Sternum.*** Note the two facets on either side for articulation with the Collar Bone and first Costal Cartilage. Also note the half facet for the 2nd Costal Cartilage.

(ii) Lower bigger part, tapering below, called ***Body*** or ***Shaft.*** Note the five facets on its each side for the five pairs of costal cartilages and the half facet for the 2nd Costal Cartilage on its upper edge on each side.

(iii) In the living body there is also a third part of the bone which is most often made up of cartilage called ***Xiphoid Cartilage*** or sometimes made up of bone called ***Xiphi-sternum.***

E. Upper Extremity or Upper Limb. Note in the articulated skeleton that each upper limb consists of the following bones:—

Clavicle or Collar Bone	together form the ***Shoulder girdle***
Scapula or Shoulder Blade	
Humerus or Bone of the Upper Arm.	
Ulna	***Bones of the Fore-arm.***
Radius	
Carpal or ***Wrist bones***	***Bones of Manus or the Hand.***
Metacarpal bones in the Palm	
Phalanges or finger bones	

1. CLAVICLE OR THE COLLAR BONE.

Select it and note that it is a long bone having two ends and one body or shaft with two curves. Medial end articulates with the sternum and is called the ***Sternal End*** which is triangular ; lateral end articulates with the Acromian Process of Scapula, and is flattened ; hence called the ***Acromial End.***

You can distinguish the right from the left by noting the following :—

(*i*) It lies horizontally in the body with its acromial flattened end externally, and its rounded triangular sternal end medially; internal curve has convexity forwards and external curve has convexity backwards.

(*ii*) There is a well marked grove on the under surface.

Sketch the bone and label its parts.

2. SCAPULA OR SHOULDER BLADE.

Note its triangular shape with the vertex at the outer upper angle and its base at the vertebral border. At its vertex note the smooth shallow cavity—***Glenoid Cavity***—for the head of the humerus. Also note that there is a ridge of bone on its back surface—***Spine***—which is prolonged outwards into a process —***Acromial Process***—which unites with the clavicle. The back surface is convex and the front surface is smooth and concave. Note the beak-shaped process at its upper border—***Coracoid Process.***

Identify the right with the left by noting:—

(*i*) Glenoid Cavity is at its upper outer angle,

(*ii*) There is the spine at its back surface on its upper part.

(*iii*) Coracoid process is at its upper edge.

Sketch the bone and show all the points.

3. HUMERUS OR BONE OF THE UPPER ARM.

It is the longest and largest bone of the upper limb with an upper and a lower end and a body or shaft in between. Distinguish the right from the left :—

(*i*) The upper end is round (***head***) and is projected medially for articulation with the Glenoid cavity.

(*ii*) The lower end is pulley-shaped with a single big depression—***Olecranon Fossa***—for the Olecranon of Ulna on its back surface.

Sketch it.

4. BONES OF THE FORE-ARM.

(*a*) ***Ulna or the inner bone***, i.e. the bone towards the little finger.

Note that at its upper end it has a beak-shaped projection called the ***Olecranon Process*** behind and a smaller ***Coronoid Process*** in front; and there is the smooth articular surface in between them with concavity forwards. Its lower end is very small and has a small projection (Styloid Process) on its inner part.

Determine the side by:—

(*i*) Olecranon is at its upper end with concavity forwards.

(*ii*) Styloid process is at the smaller lower end at its medial part.

(*iii*) There is a smooth facet for the revolution of the head of the radius at the outer aspect of the upper end.

(*vi*) The sharp edge of the bone for the Inter-Osseus Membrane is at its outer side.

It is the longer of the two bones of the fore arm.

(*b*) ***Radius or outer bone*** i.e. the bone towards the Thumb.

Note in this that, unlike ulna, the upper end is smaller and the lower end is bigger. The upper end is round and has a cup-shaped depression above for articlulation with the humerus, and the rounded collar like edge of upper end revolves on the facet at the outer side of the ulna. Determine the side.

(*i*) Upper end is smaller, round and cupped.

(*ii*) Lower end is bigger and has a smooth surface in front; and a grooved surface for the passage of the tendons behind.

(*iii*) Styloid process at its lower end is situated laterally.

(*iv*) Sharp edge of the bone is directed medially.

This bone is shorter than the Ulna.

Note that in between the Styloid Processes of both bones there is a protected space into which four Carpal bones of the First or Proximal row fit.

5. BONES OF MANUS OR HAND.

(*a*) ***Wrist Bones or Carpal Bones.*** They are eight, short cuboidal bones, arranged in two rows of four each. They slide over each other to allow a free range of movements.

(*b*) ***Meta-Carpal Bones*** or ***the Bones of the Palm.*** They are five in number and are small sized long bones forming the palm of the hand in between the carpal and the finger bones.

(c) ***Phalanges*** or ***bones of Fingers.*** They are three in each finger and two in the thumb. Note how they are united to each other end to end. Draw a diagram of the whole hand.

The teacher should pick up various bones out of the lot and should ask students to identify the bones, and the side to which they belong to test their knowledge.

F. Lower Extremity or Lower Limb.—Note in the articulated skeleton that each lower extremity consists of the following bones:—

Pelvic, Innominate or Hip Bone.	Forming one half of ***Pelvic Girdle.***
Femur or ***Thigh Bone*** ***Patella*** or ***Knee Cap.***	
Tibia or ***Shin Bone.*** ***Fibula*** or ***Splint Bone.***	Bones of the Calf or the Leg.
Tarsal or ***Ankle Bones.*** ***Meta-tarsal*** or ***Bones of the Instep.*** ***Phalanges or Bones of Toes.***	Bones of the Foot or the Pes.

1. OS-INNOMINATUM OR HIP BONE.

It is a big irregular bone and is formed by the fusion of three parts which meet in the centre where they form a cup like depression called ***Acetabulum,*** on the outer surface, into which the head of Femur fits forming hip joint. The upper broad expanded portion is called ***Ilium*** (c. f. ***Ileum***—a part of the small intestine.) The lower thick part forms a prominence on which we set and which touches the ground, and is called ***Ischium***; and that pa which meets in front with its fellow of the opposite side is called ***Pubis*** forming the ***Pubic Crest.***

One can feel in his own body all these three parts,

To determine the side note:—

- (*i*) Acetabulum looks outwards.
- (*ii*) Ilium is directed upwards.
- (*iii*) Pubis is directed forwards and medially.
- (*iv*) Ischium is directed downwards.

Sketch and label its parts.

2. FEMUR OR THIGH BONE.

This is the longest and the strongest bone in the body. It has a ***shaft or body*** and an ***upper*** and a ***lower end.*** The upper end has a rounded ball-like ***head*** joined to the shaft by a narrow ***neck.*** The lower end has got two big prominences called ***Condyles.***

Note its various parts:

1. *Head*
2. *Neck.*
3. Two ***Prominences*** on its upper end called ***Trochanter majus*** and ***Trochanter minus.***
4. ***Shaft or body.***
5. Lower ***end with two condyles.***

Determine the side by:

- (*i*) The head is directed upwards and inwards.
- (*ii*) The Shaft and the lower extremity are convex forwards.
- (*iii*) There is a thick ridge or line at the back of the shaft called ***Linea Aspera.***

3. PATELLA OR KNEE-CAP.

It is a small rounded disc-like bone in front of the

Knee-joint. It can be moved from side to side when the leg is extended and the muscles are relaxed. It is a bone through which the tendon of the muscles in front of the thigh gets attached to the Tibia.

4. BONES OF THE LEG.

(*a*) ***Tibia or Shin Bone.*** Of the two bones of the leg it is the stronger and lies on the inner side. It has an upper end, a shaft, and a lower end. Upper end is flattened and shaped to receive the condyles of the Femur. Shaft is triangular and its front edge is sharp and projected below the skin, popularly called "***Shin.***" Lower end has a prominence on its inner surface - the ***Internal Malleolus***—and a part of the lower end articulates with the ***Astragalus*** to form the ankle-joint.

Determine the side by:—

(*i*) Head is upwards and flattened.

(*ii*) Sharp sub-cutaneous margin of bone (shin) is forwards.

(*iii*) Malleolus is inwards.

Sketch the bone.

(*b*) ***Fibula or Splint Bone.*** It is a slender bone lying on the outer side of the leg. It has its upper end in cuboidal form and its lower end is elongated and forms the outer prominence called the ***External Malleolus*** of the Ankle. Its upper end joins with Tibia below the knee-joint so that the ***Fibula takes no part in the formation of knee-joint,*** unlike elbow joint. Also unlike radius to which it corresponds, it does not rotate round the Tibia.

Determine the side by noting:—

(*i*) Head is small and cuboidal, and is directed upwards.

(*ii*) Lower end is enlongated and the articular facet on it is directed inwards.

(*iii*) Little eye-like depression at this facet is near the hinder border.

5. BONES OF THE PES OR FOOT.

Tarsal or Ankle Bones. They are seven in number, unlike eight in the upper limb. Note that in between the two malleolii of Tibia and Fibula and under the articular surfaces at the lower ends of these two bones you see a thick bone called ***Os Astragalus or Talus bone.*** This is the bone which forms the ankle joint with Tibia and Fibula; ard flexion and extension movements take place. This bone (Astragalus), in turn, is placed on another important bone—the lowest bone in the body—called ***Os Calcis*** or ***Os Calcaneous*** or ***Heel Bone*** which is projected behind to which is attached the strong ***Tendon of Achilles or Tendo Achilis*** of the muscles of the calf.

Meta-tarsals. Five in number. Note that they are shorter and thicker than the metacarpals, as they have to support the body weight.

Phalanges. Are 14 in number (c.f. Phalanges in hand) They are small and thick.

Draw a diagram of the foot as seen from above.

Note the two arches of the foot, a Transverse and a Longitudinal arch. They are meant to absorb the shock in walking and jumping, and give elasticity and smoothness to our gait.

N.B. The teacher should also select various bones and should ask the students their names and the sides and how they fit into the body.

APPEARANCE OF A DECALCIFIED BONE.

Expt. I. Get a piece of fresh bone from a butcher's shop. Feel how hard it is. You can neither bend it easily nor press it. Weigh it and record its weight in your notebook with date.

Next place it in dilute hydrochloric acid (2 %) in a glass jar. If necessary after a few days' interval, change the acid.

After a week or two take it out of the acid, dry it, and again record its weight. Note the difference in weight. It is lighter, more flexible and soft, and can be turned into shreds showing its fibrous nature. You can now bend it in any direction. Account for the difference in weight and flexibility.

N. B. The reason for the above change is that the dilute hydrochloric acid has acted upon and dissolved the earthy mineral salts, especially of calcium, which pervade the bone and make it hard i.e. the bone has become decalcified. After this change, only the organic matter remains which can be bent.

Next place the decalcified, flexible bone in lime water and change the lime water daily for a long period. Note the difference, if any, and explain.

Calcium may again get entangled with the organic matter and so the bone may become hard.

Expt. II. Next take another piece of bone. Weigh it and record. Then place it in an iron spoon and keep it in the middle of red-hot fire for 20 minutes. See that it becomes brittle and crumbles to a white powder on touching. It retains its shape. Weigh it, and note the difference. You cannot now bend it, but you can easily break it. The organic matter is all burnt and the mineral matter i.e. the calcium salts, remains as the ash.

From these *experiments write roughly the composition* of the bone. What is the difference in the composition between the bone of a small child and that of an old man ?

In old men the bones contain more calcium and less organic matter, hence they are easily broken. In children they contain more organic matter and less calcium and so they do not easily break but get bent, hence the Green-stick fracture in them.

From these two experiments what do you infer regarding:—

(*a*) the proportion of organic and inorganic matter present in the bone,

and (*b*) the function of organic and inorganic matter in the bone?

The teacher should explain to the class why we did not use strong hydrochloric acid in the first experiment, as it would have burnt the organic matter also.

TYPES OF JOINTS.

When two or more bones meet together they form what is called a ***Joint or Articulation.*** Joints are divided into two classes:—

(1) Immovable or Fixed Joints.

(2) Movable Joints.

IMMOVABLE JOINTS. They are classified into:—

(*a*) Sutures and

(*b*) Symphysis.

(*a*) ***Sutures.*** These are formed by the inter-locking of the bones of the skull. These bones are firmly united together by a saw-like edge of one bone interlocking with the similar edge of the other bone to form a bony union called ***Sutures.*** These joints permit little or no movement. The object of these joints is to give considerable strength combined with rigidity to the bones protecting the brain inside.

(*b*) ***Symphysis.*** Here the articular surfaces are covered by an articular cartilage and are connected by a broad disc of fibrocartilage e. g. Symphysis Pubis, and the joints between the bodies of the Vertebrae. The bones are firmly joined together by ligaments. Slight movement is possible in such joints.

MOVABLE JOINTS. These joints allow one or more of the following movements:—

(1) Flexion:—Bending of a joint.
(2) Extension:—Straightening of a joint.

(3) *Adduction:—Movement towards the mid-line of the body; or, in the case of fingers and toes, towards the mid-line of hand or foot.*

(4) Abduction:—Movement away from the mid-line of the body or, in the case of fingers and toes, away from the mid-line of hand or foot.

(5) Rotation:—Movement along the long axis of the movable bone or movement round the long axis of the fixed bone.

(6) Circum-duction:—Combination of all the above movements.

The movable joints are classified into:—

(*a*) ***Ball and Socket Joint.*** In this the rounded ball-like head of one bone fits into the cup shaped cavity of the other bone e.g., hip and shoulder joints. This kind of joint allows all the movements.

(*b*) ***Hinge Joint.*** The bones are united like the hinge of a door and like that allows only two movements, flexion and extension, e.g. knee, elbow and inter-phalangeal joints.

(*c*) ***Pivot Joint.*** In this joint:—

(i) Either one bone forms a fixed pivot around which the other bone rotates like a ring (the ring being formed partly of bone and partly of ligament) e.g. the joint between Odontoid process of Axis and the Anterior Arch of Atlas by which we move the head from side to side i.e. the Atlas (ring) carrying the skull with it moves round the Odontoid Process of axis (pivot).

(ii) Or the pivot-like process of one bone rotates within the ring formed partly by the other bone and partly by ligament e.g., the proximal radio-

ulnar joint by which the movements of supination and pronation occur (i. e. movement of the forearm with palm upwards or with palm downwards). Here the round head of radius revolves in the ring formed by the radial notch of the ulna and the annular ligament.

(*d*) ***Gliding Joint.*** In this joint the various bones forming the joint glide or slide over each other e.g. in joints between carpal and tarsal bones, jaw-joint, a joint between acromial end of clavicle and acromial process of scapula, joints between articular processes of the vertebrae etc.

Study all the joints in your body and tabulate as under :—

Name of the joint.	Type of the joint.	Bones forming the joint.	Movements allowed

Get from the butcher's shop a shoulder or an elbow joint of a sheep and study the mechanism of joints. Note that the joint is covered all round by a bag like thing called the ***Capsule of the Joint*** which is made of fibrous tissue. This capsule is at some places much thicker, and these thick and firm bands are called ***Ligaments of the Joint.*** Also note that the bones forming the joint are not bare but are tipped with a very thin plate of cartilage called ***Articular Cartilage.*** Also see that the whole of the cavity formed by the capsule is lined by a thin membrane called ***Synovial Membrane*** which secretes ***"Joint Oil" or Synovial Fluid*** which lubricates the joint.

Make a diagram of this joint showing all these details.

NATURAL LEVERS

A lever is a rigid bar or rod which moves about a certain fixed point, called Fulcrum "F". The force spent in using the lever is called Power "P", and the work done or resistance overcome is the weight "W". Thus a lever is an arrangement for applying force in the easiest possible manner so as to cause movement or overcome resistance. The chief movements of the limbs and head performed by the skeletal muscles are examples of the principles of lever.

The ratio which the work done by a machine bears to the power spent is called the ***Modulus*** or ***Mechanical Advantage*** of that machine. ***The Modulus*** is positive when the ratio is greater than 1, or negative when it is less than 1, i.e. when modulus is greater than 1, there is mechanical advantage in using the machine, and when modulus is less than 1, there is disadvantage in using that machine. The distance between "F" and "P" is ***power-arm***, and that between "F" and "W" is ***weight-arm***,. Suppose "P" denotes power spent, and "W" denotes the work done, then

P × Power-arm is always equal to W × Weight-arm.

$$\text{i.e. } \frac{W}{P} = \frac{\text{Power-arm}}{\text{Weight-arm}}$$

$$\text{But } \frac{W}{P} = \text{Modulus of the machine.}$$

$$\text{Hence Modulus “M”} = \frac{\text{Power-arm}}{\text{Weight-arm}} = \frac{FP}{FW}$$

Levers are divided into three kinds or orders according to the relative positions of F, W and P.

First Order. Here F is between W and P. The common balance, or the pair of scissors, is a very good example of it. In such a lever any arm may be bigger or both may be equal, so M = 1 or less than 1 or greater than 1.

Study the following examples in your own body :—

(*a*) ***Nodding movement of the head.*** Here the Fulcrum is the joint between the condyles of the Occipital bone and the Atlas Vertebra, and the muscles in front and back of the neck attached to the front and back of the skull are respectively the Power and the Weight as the head is moved forwards; and vice versa when the head is moved backwards.

(*b*) ***Extension of the fore-arm by triceps at the back of the arm.*** Triceps is attached to the tip of the ***Olecranon*** of ***Ulna.*** Then adjacent to it is the articular surface of the Ulna forming the elbow joint. In front is the weight of the fore-arm and hand. In straightening the fore-arm Power is exerted by the Triceps at the tip of the ***Olecranon,*** and Fulcrum is the elbow joint in the middle, and the weight of the fore-arm and the hand is at the other end. P is applied at the end of the short arm, thus secures rapidity of action and a wide range of movements.

(*c*) ***Working on a sewing machine with foot.*** F is at the ankle-joint, tendon of Achilles attached to Os Calcis (Heel bone) is the P, and Weight is at the toes where the machine is pressed down.

Sketch these showing F. W. and P.

Second Order. Here W is between F and P.

In this FW (Weight-arm) is always smaller than FP (Power-arm), so M is always greater than 1 i. e. there is always mechanical advantage in using this machine. Common example in daily life is a man lifting a wheel-barrow or breaking a nut with a nut-cracker. Note the following examples in your own body:—

(a) ***Raising the body on the toes.*** When we stand on tip-toe, the calf muscles raise the body by applying force at the Os Calcis through the tendon of Achilles and the Weight is that of the whole body transmitted through the ankle-joint. Fulcrum is the spot where the toes touch the ground.

(b) ***Lifting one leg off the ground.*** In this hip-joint is the Fulcrum, Weight is that of the thigh, leg, and foot, felt a little above the knee joint and Power is applied by the muscle which extends from hip-bone to knee-cap at tibia a little below the knee joint.

Sketch showing F. W. and P.

Third Order.

Here P is between F and W. In this FP (Power-arm) is always smaller than FW (Weight arm) i. e. M is always less than 1 i. e. rapidity and a wide range of movements are gained at the expense of power in using this machine.

Common example in every day life is holding anything by a pair of tongs.

Note the following in your own body :—

(a) ***Bending the fore-arm.*** In this F is at the elbow-joint, W about the middle of the fore-arm is the weight of the hand and the fore-arm, and P is applied by the Biceps at the Radial tuberosity in between the middle of the fore-arm and the elbow joint.

(b) ***Extension of leg after bending.*** In this F is at the knee-joint, leg and foot are the weight to be moved, and P is applied at Tibial tuberosity by the extensor muscles of the thigh in between the knee-joint and the middle of the leg.

Sketch these showing F. W. and P.

Study the following movements, sketch them, showing the positions of F, W and P, and thus deduce to which kind of lever each belongs and tabulate as under:—

1. Carrying a heavy ball in the palm.
2. Bending of the leg.

Movement.	Position of F, W and P.	Order of the Lever.
1.		
2.		

VISCERA IN A DISSECTED RABBIT.

Note that there are two large cavities in the trunk which are separated by a dome-like partition made up of a muscle called *Diaphragm.* Note its convexity towards the upper (Thoracic) cavity, and its con-cavity towards the lower (Abdominal) cavity.

Study the organs in both the cavities separately, first in an undisturbed condition (i.e. in situ), and then by displacing them or even, if need be, by dissection.

1. Abdominal Viscera.

(A) IN SITU (UNDISTURBED).

Note that all the organs in this cavity are enclosed by a thin membrane which forms a cover for all, called the *Peritoneum.* Cut the peritoneum in the middle and reflect it on either side, and note:—

(1) *Liver.* A large dark red mass lying just underneath the diaphragm having five parts or lobes. In human beings there are only two lobes, left smaller than the right. Liver is mostly on the right side.

(2) *Stomach.* It lies in the mid-line, is of a bluish white colour, sometimes distended with food and is partly covered by Liver. Only a small portion is visible in situ.

(3) *Small Intestine.* Note several coils of a whitish worm-like tube showing waves of contraction (Peristalsis) in a freshly killed animal. These are also mostly distended with gas. They are partly covered by the large intestine.

(4) *Large Intestine.* It is a wide sacculated grey coloured tube covering most of the abdominal viscera and runs across the abdomen.

(5) ***Urinary Bladder.*** In the mid-line at the lower part of the abdomen you may see a thin walled sac partly visible and partly hidden behind the symphysis Pubis. It can be easily seen coming out from behind the Public bones when full of urine.

Draw a diagram of the abdominal viscera in situ.

(B) DISTURBED.

(1) Tilt the liver upwards and note on its under surface a green elongated pear-shaped bag known as the ***Gall Bladder.***

(2) Pass your finger from the front surface of the stomach upwards and towards the left, you will note that the stomach decreases in width till it pierces the ***Diaphragm.*** This is the junction of the ***Gullet*** with the stomach called the ***Cardiac Orifice.*** This is the upper end and opening of the stomach. Also note the lower end called the ***Pyloric Orifice*** which is towards the right of mid-line, where it joins with the small intestine.

(3) After turning the stomach upwards you will find on its under surface and a little towards the left the ***Spleen*** which is small, flat, dark-red and elongated. It is attached to the cardiac end of the stomach by a sheet of peritoneum. In human beings it is to the left of the stomach and not under it, and is much larger.

(4) Trace the small intestine from the pyloric end to its junction with the large intestine.

(*a*) The first part is called the ***Duodenum.*** It forms a C shaped loop with its con-cavity towards the left. It ends at a sharp bend. In its con-cavity you can easily see a white and elongated, diffuse gland called the ***Pancreas*** consisting of a number of small lobules looking like masses of fat spread all over the mesentary which connects the two limbs of the duodenum.

(*b*) Also note that a tube—the ***Common Bile Duct***—enters the dorsal side of the doudenum by a prominent aperture a short distance beyond the pylorus. See that the common bile duct is formed by the union of several ***Hepatic Ducts*** from the lobes of the liver with the ***Cystic Duct*** from the gall-bladder.

(*c*) Note that the small ducts from the various lobules of the pancreas run together to form the main ***Pancreatic Duct*** which opens, independent of the common bile duct, into the distal limb of the duodenum nearly two inches beyond the bend.

(*d*) The remaining part of the small intestine beyond the sharp bend is called the ***Ileum*** (c. f. spelling of Ilium—a part of hip bone). Sometimes the first one-third of this Ileum is called the ***Jejunum*** and the remaining two-thirds is called the Ileum.

At the junction of the ileum and the large intestine note a valve called the ***Ileocaecal Valve.*** The whole of the small intestine is 7 or 8 feet long.

(5) Then examine the large intestine.

(*a*) The first part with which the ileum joins is the thin-walled ***blind gut or Caecum.*** See that it is very wide and is dark grey in colour, and lies coiled on itself. It is recognized by having a spiral constriction throughout its length. It ends blindly in a small finger-like ***Vermiform Appendix.***

Note that the ileum joins the caecum about an inch from the end opposite to the vermiform appendix, and that the large intestine beings from the same end. Caecum is much larger in rabbits than in man.

(*b*) The second part which runs obliquely across the abdomen is the ***Colon.*** Its walls are sacculated and is about 1½ feet long. It is narrower than the caecum.

(*c*) The colon passes insensibly into the third, still narrower part called the ***Rectum.*** It is nearly of the same diameter as the small intestine. It is the last part of the large intestine and is easily recognised by its containing pellets of faecal matter here and there. Its walls are not sacculated.

Compare the positions of the different parts of the large intestine of human beings with those of the rabbit by looking at the Physiology chart.

Next turn all the intestines to your right, and see the organs at the posterior wall of the abdomen. It may be necessary to do a little dissection.

Note that :—

(1) There are two bean shaped dark-red organs—the ***Kidneys***—attached to the dorsal wall, one on either side of the vertebral column. The right one is slightly more towards the thorax than the left. In front of each towards its inner side one may note a small yellowish body—***Adrenal*** or ***Suprarenal Gland***—on either side of the Aorta.

(2) See carefully the inner margins of both the kidneys. You will find that from each a fine white tube passes downwards. Trace them below and see that they enter the Urinary Bladder. These are called the ***Ureters.*** See also the blood vessels of the kidneys, the thick reddish artery entering in, and the bluish vein coming out.

(3) Note that the intestine is hung up to the posterior wall of the abdominal cavity by a double layered thin transparent membrane—the ***Mesentery.*** This thin membrane also covers all the abdominal viscera and is then called the ***Peritoneum.***

Examine one of the coils of the small intestine. Passing from its border is a thin transparent membrane containing blood vessels. This membrane attaches the intestine along its whole length to the vertebral column at the back of the abdomen. This is called the ***Mesentery*** as explained above.

(4) Going by the side of the vertebral column note a big blue blood vessel called the ***Inferior Vena Cava.*** Also see the abdominal Aorta—a big red thick blood vessel entering the abdominal cavity after piercing the diaphragm at the back of the stomach, downwards a little in front of the vertebral column.

Next note the three openings in the diaphragm viz:— the first for the gullet, the second for the abdominal aorta; and the third for the inferior vena cava. Out of these, the hole for the aorta lies most posteriorly and a little to the left of mid-line; the hole for the gullet lies most anteriorly and in the middle or a little towards

the left; and that for the inferior vena cava lies behind the liver much to the right side of the mid-line.

Make a diagram of the posterior abdominal wall with the organs you see there.

(5) ***Urinary Bladder.*** It is a thin walled sac in the lower part of the abdomen.

(6) ***Spleen.*** It is an elongated dark red body lying behind the stomach and attached to its left end by a sheet of the mesentery.

2. Thoracic Viscera.

Examine the thorax and see how it is made. It is a bony cage made up of 12 dorsal vetebrae, 12 pairs of ribs and a breast bone.

(1) The first thing you see in this cavity is the ***Heart.*** It will be found beating in a freshly killed rabbit. Mark that it is lying more to the left than to the right of the mid-line of the body. Also note that the organ is completely covered in a thin transparent sac called the ***Pericardium.***

Remove the pericardium by dissecting it. Then note that the heart is dark in colour and conical in shape, the apex being directed downwards and slightly to the left and forwards; and the base with the roots of the great vessels upwards and slightly to the right and backwards. If the heart is still beating you can easily note that the upper part thereof (Auricles) contracts first and the lower part (Ventricles) afterwards.

(2) On either side of the heart you see a big spongy reddish organ of respiration called the ***Lung.***

(3) Coming down the neck and entering the thorax one can easily see a tube which as it

goes downwards divides into two branches, one going into each lung. This rigid tube is known as the *Trachea* and its branches are called the *Bronchi* (sing. Bronchus). Rigidity of the trachea is due its containing in its wall C shaped rings of cartilage deficient behind.

Note:—The teacher should explain to the class why the rings of the cartilage are deficient behind.

(4) Behind the trachea one can see a soft tube which continues from the neck into the thorax and crosses the cavity in the mid-line, and leaves by piercing the diaphragm. This flexible tube is called the ***Food pipe*** or the ***Gullet*** or the ***Oesophagus***

Now you should examine the blood vessels entering and leaving the heart. In the upper chambers (Auricles) enter the following blood vessels:—

On the right side three big vessels, blue in colour—i.e. two Superior Vena Cava from above and one Inferior Vena Cava from below; on the left small Pulmnory Veins which are red in colour and two in number. From the lower chambers (Ventricles) come out two big blood vessels i.e. Pulmonary Artery, blue in colour from the right, and *Aorta* a big red vessel, from the left.

By pulling out a lung you can know that it is enclosed in a very thin membrane called the ***Pleura.***

Make a sketch of the thorax showing its contents and boundaries as seen from the front. Give the functions of the various blood vessels entering and leaving the heart.

N. B. The description given in this chapter is that of a rabbit lying on its back on the dissection board with its ventrum facing us and head upwards and tail downwards.

THE HEART.

Get a sheep's heart from a butcher and see that it is wholly covered by a thin transparent membranous sac called the ***Pericardium.*** Distinguish the front (Anterior) surface from the back (Posterior) one by:—

(1) The apex of the heart is formed entirely by the left ventricle.

(2) The inter-ventricular groove is more distinct and quite well marked in front.

(3) The front aspect of the heart is more convex. This you can only see if the heart is quite hard and firm at the time of the examination.

Remove the pericardium by a little dissection and see that the heart is divided by a white horizontal groove into an upper and a lower part.

The upper part is smaller and collapsed, and is formed by the ***Auricles*** (looking like ear) or the receiving chambers, and the lower part is bigger and thicker and is formed by the ***Ventricles*** or the propelling chambers.

Place the heart with the front side facing you and the auricular part above and the ventricular part below. In this position note that the apex is below and the base of the heart is above (the shape of the heart being like a cone). On your right of the inter-ventricular groove is the left ventricle forming the apex, and on your left is the right ventricle. Note that the walls of left ventricle are thick and firm as compared with the right ventricle. Also note that the walls of the auricles are much thinner than those of the ventricles. Along the auricles you will find deep-red or purple coloured fleshy masses called the ***Auricular Appendages.***

Next find out the blood vessels entering and leaving the heart. Into the right auricle open the ***Superior Vena Cava*** and the ***Inferior Vena Cava.*** Into the left auricle open the two ***Pulmonary Veins*** (in human beings there are four instead of two). From the right ventricle comes out the ***Pulmonary Artery*** which then divides into two branches, one for each lung. From the left ventricle comes out a very big artery, the curved ***Aorta*** which supplies pure blood to the whole of the body.

Draw a diagram of the heart showing the bood vessels leaving and entering it.

Then cut the heart to show the inside of the four chambers of the heart. Examine the inside of each.

(1) The interior of the auricles has some comb-shaped masses (***Musculi Pectinati***). Pass a probe from the superior vena cava and inferior vena cava and see that it reaches the right auricle. Similarly see that the two pulmonary veins from the lungs go into the left auricle.

(2) Note the opening between the right auricle and the right ventricle called the ***Right Auriculo Ventricular Orifice*** which is guarded by a valve (a mechanism which allows blood to flow in one direction only) called the ***Tricuspid Valve*** with three ***flaps or cusps.*** Note that the three cusps are triangular in shape with their bases attached to the margins of the orifice. To the apices and the sides of the flaps are attached very fine thread-like strings called ***Chordae Tendinae*** (Cord-like tendons) and these, in their turn, are attached to little raised projections of muscles on the

inside of the right ventricle called ***Musculi Papillares*** or ***Papillary Muscles.*** These are found in each ventricle. Also note that the chordae tendinae are just long to allow the three flaps to close the orifice so that the flaps cannot fall into the auricle.

(3) Note that the walls of the ventricles are more rough than auricles.

(4) Next see carefully the opening of the pulmonary artery from the right ventricle. This opening is also guarded by a valve called the ***Semilunar Valve*** (half moon). Note that the valve consists of three pockets or cups appearing like half moon which open towards the artery and are attached towards the ventricles. These pockets allow the blood to pass over them from the right ventricle to the pulmonary artery, but when the blood tries to go back from the pulmory artery to the right ventricle (i.e. when the right ventricle is in a state of relaxtion), the pockets get filled with blood and meet in the centre, and thus the opening is closed.

(5) Running across the cavity of the right ventricle you can also see a muscular band which extends from the anterior wall to the ventricular septum. It prevents over-distension of the ventricle ard so is called the ***Moderater Band.*** This structure is absent in human hearts.

(6) Next examine the left auricle and the left ventricle and see all the structures which you saw on the right side excepting:—

(*a*) Instead of superior vena cava and

inferior vena cava there are two pulmonary veins.

(*b*) The valve at the left auriculo-venticular opening is the ***Bicuspid*** or the ***Mitral valce*** formed of two cusps only.

(*c*) The moderator band is absent.

(*d*) The cavity of the left ventricle is bigger than that of the right ventricle.

(*e*) The walls of the left ventricle are much thicker than these of the right ventricle.

(*f*) Aorta comes out from the left ventricle instead of the pulmonary artery, and they cross each other after origin, pulmonary artery being in front.

(*g*) The apex of the heart is formed by the left ventricle.

1. Sketch the dissected heart and the things seen. 2. Make a rough sketch of the heart and show the circulation of the blood through it by arrow-heads.

THE TRACHEA AND THE LUNGS.

Get from a butcher the trachea and the lungs of a sheep or goat. Examine the Trachea. See it is a tube which left to itself remains widely open.

This is because it contains a series of cartilaginous rings, joined to each other, which are incomplete on one side i e. they are C shaped.

This side where they are incomplete, is filled by a thin membrane which forms the back of the trachea and is in contact with the food pipe.

The teacher here should explain to the class the value of these rings in always keeping the trachea open and why they are incompelete behind.

Trace the trachea below and see that it divides into two branches (Bronchi), each bronchus going into each lung. The place where the bronchus enters the lung is called the ***Root of the Lung*** which consists of a bronchus, a pulmonary artery, a pulmonary vein, nerves and lymphatics. Note the smooth inner lining of the trachea.

Lungs are soft, elastic, spongy structures somewhat conical in form and of a pinkish colour. Note that each lung consists of a number of lobes or parts (in human beings two in the left and three in the right). The outer surface of each lung is patchy and pigmented. Press it and see that it crepitates and some frothy fluid comes out. When released it resumes its position due to elasticity. By bellows you can blow air into the lungs and see that they swell up and increase in size. If the lungs are placed in a trough in water they float. Why?

Cut one lung boldly with a knife and see the openings of little bronchial tubes which are patent here and there. Some blood vessels may also be seen.

Sketch the trachea and the lungs showing lobes etc.

THE KIDNEYS

Get a sheep's kidney and proceed to examine it.

(1) Note the general shape. It is a dark red, bean-shaped organ. Its exterior border is convex and interior is concave. Its anterior and posterior surfaces are convex. About the middle of its inner border there is a depression or cleft called the ***Hilum or*** the ***Hilus***, the place where the three structures (the renal artery, the renal vein and the ureter) either leave or enter the kidney.

(2) *Each kidney* is covered by a very *thin* membrane called the ***Capsule of the kidney.***

(3) From the three structures which enter the hilus, select a white tube (***Ureter***) and see that it is wide as it comes out of the kidney; and as it runs down, it narrows. Trace it down and see that it enters into the urinary bladder.

Then dissect the kidney longitudinally from the outer border to the inner into two halves.

Note:—

(*a*) The outer darker, and granular portion called the ***Cortex.*** The granular appearance is caused by the presence of ***Bowman's Capsules,*** or ***Malpighian Capsules.***

(b) The inner part lying next to the cortex is the ***Medulla.*** It is paler and lighter in colour, and is streaked in appearance. Note specially the conical, red, streaked masses with their apices inwards, and bases directed peripherally. These are called the ***Pyramids.*** They are six in sheep's kidney and 12 in human kidney. These pyramids open into a funnel-shaped cavity formed by the expansion of the ureter within the kidney called ***Pelvis of the kidney.***

At the apices of the pyramids one can see very minute openings which are the openings of the ***Uriniferous Tubules.*** Press the pyramids and you will see the urine pouring into the pelvis in tiny droplets.

(*c*) The innermost part is the Pelvis of the kidney. The pyramids divide the pelvis of the kidney into a great many cup-like portions which are called the ***Calyces.*** The pelvis communicates with the ureter. Pass a bristle from the pelvis into the ureter. Also see the blood vessels of the kidney.

Sketch the kidney as a whole and as dissected; and label their parts.

MODEL OF EYE

Note, in the model of the eye put before you on the table that:—

(1) It is a round ball-like organ, to the back of which is attached a stalk like thing called the ***Optic Nerve.***

(2) (*a*) The anterior 1/5th of the ball bulges slightly, being a portion of a smaller sphere, called the ***Cornea*** which is transparent. Through this you see a coloured, streaked, round curtain—***Iris***—having a central very dark round hole in it called the ***Pupil.***

(*b*) The posterior 4/5th is thick, white, and opaque called the ***Sclerotic coat*** or the ***fibrous coat*** or the ***outer coat*** or th ***Sclera.*** To its outer side see the attachments of the six muscles of the eye-ball. The cornea is a part of this coat with this difference that it is thin and transparent.

The teacher should explain the movements of the various muscles of the eye-ball by telling their origins and attachments, i. e. the four recti and the two oblique muscles.

(*c*) Note that the optic nerve enters the interior of the eye-ball by piercing the outer coat. What are the uses of this coat?

(3) The Middle coat is the vascular coat because it supplies nourishment to the other coats. It is divided into two parts as follows:—

(*a*) the hinder part inside the sclera is called the ***Choroid.*** Note its black colour. Why?

(*b*) The part seen through the cornea and lying behind it, is called the ***Iris.*** It is like a curtain and lies some distance behind the cornea, and is nearly flat. It is not curved like cornea or choroid. Its colour differs with individuals and races. It is seen to be made up of radiating and circular fibres.

(c) There is a rounded hole in the centre of the iris called the ***Pupil.*** It is through this hole that rays of light pass into the eye. Through the cornea you see the pupil like a round, small, very dark spot. The pupil gets bigger in shade and smaller in light due to the movements of the muscle fibres in the iris.

The teacher should explain how the contraction and dilatation of the pupil is brought about by telling that there are two kinds of fibres, the radial and the circular.

(a) See the rotating folds or plaits into which the choroid is thrown, before it passes into the iris called the ***Ciliary Processes.*** Between the ciliary processes behind and the corneo-scleral junction in front there is a circular band of muscle called the ***Ciliary Muscle*** which arises from the inner surface of the junction of the cornea and sclera and passes backwards to be inserted into the outer surface of the junction of the choroid and the iris.

What is the function of the ciliary muscle and the ciliary processes?

Note that the optic nerve pierces the second coat also.

(4) The Innermost coat (***Retina***) is the nervous coat. Mark that it is only the expanded part of the optic nerve. It lies inside the choroid and extends forwards to the same length.

(5) The ***Crystalline Lens:***—

See that it is placed just behind the iris and the pupil. It is biconvex, clear, and transparent.

It is wholly covered by a thin transparent membrane called the ***Capsule of the Lens.*** It is held in place by a ligament attached to the outer surface of the capsule of the lens. This ligament in turn is attached to the ciliary processes which make the lens thicker or thinner during Accommodation.

(6) ***Chambers:—***

The space between the iris and the cornea is the ***Anterior Chamber*** filled with a watery fluid called the ***Aqueous Humour,*** and the space between the lens and the retina is called the ***Posterior Chamber*** filled with a thick gelatinous fluid called the ***Vitreous Humour.***

The blood vessels in the eye-ball may also be seen.

The teacher may obtain a sheep's eye and may place it in ice for a day or so. After that period it will become hard. Then with a sharp razor it may be cut cleanly from front to back into two equal halves. All the structures mentioned above can be easily seen in this.

(1) Sketch the eye-ball showing the three coats, two chambers, and the lens. (2) Sketch the path taken by the light rays to reach the retina.

MODEL OF THE EAR.

Note in the model of the ear provided, that it is divided into three parts; ***external, middle*** and ***internal ear.***

The External Ear. It consist of two parts:—

(*a*) An outer expanded part which projects from the head outwards called the ***Pinna or the Auricle*** which is popularly called Ear in English. It is thrown into elevations and depressions and is made up of cartilage covered with skin. It is to collect and direct the sound waves.

(*b*) From it leads a canal inwards called the ***External Auditory Canal*** which is cartilaginous in its outer part and bony in its inner part. These parts are covered by skin and mucous membrane respectively. Its outer opening (***External Auditory Meatus***) is open while its inner opening is closed by a white thin membrane called the ***Tympanic Membrane*** or ***The Membrane of the Drum of the Ear.*** This separates the outer ear from the middle ear. The sound waves strike against it, and set it in motion.

2. The Middle Ear or the **Tympanum.**

This is a small cavity with four walls, a roof and a floor in the substance of the temporal bone itself as if it is excavated into the bone. Note that:—

(1) The outer wall is mainly formed by the tympanic membrane.

(2) In its front wall near the floor and inner wall there is an opening of a tube which runs forwards and inwards to the pharynx called the ***Eustacheean Tube.*** So it connects the middle

ear with the throat to equalise pressure on both sides of the membrane of the drum; and saves the membrane from rupturing in case of sudden noise e.g. explosion, etc.

(3) There are two small holes, each fitted with a membrane on the inner wall. The upper and posterior one is oval in shape and so is called the ***Oval Window*** (***Fenestra Ovalis***) into which the foot-plate of the stapes bone fits.

The lower and anterior one is round in shape and so is called the ***Round Window*** (***Fenestra Rotunda***).

(4) On its posterior wall there is a hole by which the drum is connected with the spongy bone behind.

(5) The roof is formed by a thin plate of bone which separates it from the brain which lies above it.

(6) The floor is also formed of bone which separates it from the Internal Carotid Artery as it enters into cranial cavity.

Then see the things lying in this chamber. These are three tiny bones or ossicles, viz:—

(*i*) ***Malleus***

(*ii*) ***Incus***

and (*iii*) ***Stapes***

Note that the Malleus is shaped like a hammer, hence called the ***Hammer Bone*** and is the outermost bone. Its handle is attached to the centre of the inner side of the tympanic membrane and stretches across the cavity of the middle ear. This bone is attached medially to the ***Incus or*** the ***Anvil Bone*** which in turn, is attached to the ***Stapes*** or the ***Stirrup Bone.*** Note that the foot-plate of the stapes is attached to the upper and posterior opening on the medial wall of the cavity i. e. the oval-window.

3. The Internal Ear or Labyrinth.

Note that this complicated apparatus is constructed inside the pyramidal or ***Petrous*** portion of the temporal bone. It consists of an outer structure made of bone called the ***Bony Labyrinth*** which completely encloses another inner structure of nearly the same shape which is made of thin membrane called the ***Membranous Labyrinth.*** The latter contains a clear watery fluid called the ***Endolymph,*** and in the space between it and the bony labyrinth there is another fluid called the ***Perilymph.***

Next note that each labyrinth consists of three parts:-

(1) A central oval chamber called the ***Vestibule.*** See that it is placed opposite the oval window. Also see that there is an oval window on the outer wall of the vestibule which is fitted with membrane and into which the foot plate of the stapes gets inserted. In front and a little below the vestibule communicates with the spiral structure called the ***Cochlea.*** Above and behind it is connected with the three ***Semi-circular Canals.***

(2) ***Semi-circular Canals.*** They are three in number. Note that they lie in different planes at right angles to each other, one being horizontal and two verticle.

N. B. The teacher here, should explain to the class how these canals lie, by giving the example of an open book standing vertically on the table.

Also mark that one end of each canal is dilated into a swelling called the ***Ampulla*** to the inside of which fibres of a branch of the 8th (Auditory) nerve are

distributed. See that each canal begins from the vestibule and after forming a sort of semicircle ends in the same. Also note that two canals unite before opening into the vestibule, so that the three canals communicate with it by five openings (and not six).

(3) ***Cochlea*** lies in front of the vestibule and is like a snail shell in shape. It is also hollowed out in the solid bone. There is a central pillar called the ***Modiolus,*** round which the long spiral tube winds two and a half turns. This spiral tube is divided into two canals, an ***Upper*** and a ***Lower*** by a thin, long bony partition which runs through the entire length. These two canals are connected with each other at the top of the spiral and no where else. At the other (i. e. the lower) end of the spiral tube one of these canals (i. e. the upper) opens directly into the vestibule; while the other (i.e. the lower), leads to the chamber of the middle ear through the round window.

Remember that the membranous labyrinth is half in size to the bony labyrinth. In the fluid in the membranous labyrinth (i.e. Endolymph) some bony particles like sand float, called the ***Otoconia*** or ***Otoliths.*** Every movement of the fluid itself throws these minute particles of sand from side to side. The 8th nerve goes to the internal ear, and its fibrils spread at last over the inner walls of the membranous labyrinth in two branches, one going to the vestibule and the ampullae at the ends of the semi-circular canals, the other branch leading to the cochlea. On the central wall of the cochlea rest a great number of minute fibrils side by side called the ***fibres of Cortie.***

N.B. The teacher should explain to the class the mechanism of hearing and the functions of Fibres of Cortie, Otoliths, and Oval and Round Windows.

Make a drawing of the ear showing all these structures, and the path followed by the sound waves.

MODEL OF THE BRAIN

Study carefully the model of the Brain placed before you. One may inspect it from above, from the sides, and from below.

1. **From above:**—You see two big parts of the brain separated by a deep cleft or fissure which runs from front to back. These two parts are called the ***Cerebral Hemispheres*** and the fissure is called the ***Longitudinal Fissure.***

Each cerebral hemisphere is divided into four main lobes:—

The Frontal Lobe in front and lying under cover of the frontal bone.

The Parietal Lobe in the middle, lying under cover of the parietal bone.

The Occipital Lobe behind, lying under cover of the occipital bone.

The 4th lobe—***the Temporal Lobe***—lies under the temporal bone and is separated from the main lobes by a big fissure called the ***Lateral Fissure.***

Note how the surface of each hemi-sphere is thrown into furrows or depressions (***Sulci***) and elevations (***Gyri***). Also note the grey colour of the hemispheres.

2. **From below:**—We see the ***Medulla*** with the six pairs of cranial nerves rising from its side, the ***Cerebellum,*** the ***Pons*** and the under surface of the ***Cerebrum.*** Note that from the front part of the under surface of cerebrum there come out the two ***Olfactory nerves*** from the two ***Olfactory Bulbs.*** Also

note the ***Optic Nerves*** and their crossing the ***Optic Chiasma.*** Under the mid brain see the rounded stalked small body called the ***Pituitary Body***; and a little behind it are two small globular swellings called the ***Optic Lobes.*** Most of the cranial nerves are seen arising from this surface.

Cerebellum is also called the Lesser Brain. It consists of two lateral hemi-spheres and the connecting lobe called the ***Isthmus.*** Its surface is also thrown into folds and its colour is grey like the cerebrum.

Below the cerebellum one can see the lower-most elongated part called the ***Medulla Oblongata*** which is continuous with the Spinal Cord through the ***Foramen Magnum.*** Its colour is white (c. f. cerebrum and cerebellum). Above and in front of medulla oblongata, note a bridge-like thing called the ***Pons Varolii*** consisting of transvere fibres connecting the two halves of the cerebellum, and serves as a passage between the medulla oblongata and the rest of the brain.

3. From side. You can see the temporal lobes completely separated by the lateral fissure from the rest of the lobes.

Sketch the brain as seen from above, below, and side. Name the different parts seen in each case.

RADIAL PULSE

Pulse is the lift which you feel with your fingers when placed on any artery against some bone or cartilage. Generally we select the ***Radial Artery*** in the fore-arm, as it is placed superficially just underneath the skin on the lower end of the radius bone. (The teacher should explain the anatomy of the radial artery). This is called the ***Radial Pulse.***

Do the following experiment on yourself or on your friend:-

(1) Place the tips of first three fingers of your right hand on the lower part of the fore-arm on the front aspect in a straight line longitudinally just behind the prominance of the thumb. By gentle pressure you will feel the radial pulse rise and fall under your fingers. These are the pulsations of the radial artery. One rise and fall of the artery corresponds to one beat of the heart.

Count the pulse for exactly one minute by the second hand of a watch, and record it. This is the pulse rate per minute.

Make the person examined do a little exersise, e. g. walking briskly, running round the class room, for two to three minutes or swinging of the hands as in drill. Count the pulse again immediately after and record it. Account for the difference.

Let the person examined take rest by sitting on a chair for ten minutes, count the pulse after this rest and record.

Deductions:—

(1) Heart beats about 72 times per minute in a healthy person but anything between 65 to 80 is taken as normal, pulse rate being more in women, children, and aged persons, and less in adults and men.

(2) It increases by exercise and decreases by rest. It also increases in fever.

RESPIRATION.

I. Expose the chest and the abdomen of a friend and note that the act of breathing consists of regular series of movements. Note that, during the act of inhaling, the chest rises and the belly bulges out. Why ? It is so because the diaphragm on going down during inhaling presses down the liver, the stomach, and the spleen, and these in return descend into the abdomen and hence the bulging.

This is immediately followed by breathing out, in which the chest and the abdomen return to their ordinary size and get smaller. After that there is a pause and then the same set of movements is repeated. The first set is called ***Inspiration*** and the second is ***Expiration*** and both constitute ***Respiration.*** So one rise and fall of the chest or the abdomen constitutes one act of respiration.

(*a*) Count the number of respirations in your friend per minute by the second hand of the watch and record it.

N.B. It is not necessary to expose the chest and abdomen for counting the respiration as this can be done by counting the movements of rise and fall of the chest or the abdomen which can be easily seen even when he is in bed.

(*b*) Count the pulse per minute also in the same friend and see that the ratio of respiration to pulse is one to four.

II. Effect of Exercise on Respiration.

Let the same person do a little exercise as running, or going up and down the stairs several times and count the respiration, and record. Note that the respiration increases after exercise. Why ?

III. Effect of Rest.

Let him take rest for ten minutes. See that the respiration comes again nearly to the original.

IV. Effect of Breathing into Lime-water.

Pour some fresh lime-water in a beaker and blow into it through a glass tube. See that it becomes milky after ten or fifteen minutes. Explain. (CO_2 of the breath changes Calcium Hydroxide. $Ca(OH)_2$ into Calcium Carbonate $CaCO_3$.

V. Result of Breathing on Cold Surface.

Breathe on a looking glass or a slate. See that it becomes hazy. Why?

VI. As in No. IV above, pour some fresh lime-water in a beaker and blow into it with the bellows for 15-20 minutes. Note that the lime-water remains clear. Why?

Deduce your results from all these experiments and record them in your note book.

USE OF A CLINICAL THERMOMETER.

Get a Clinical thermometer, and one from each kind of the Laboratory thermometers. Note that the Clinical thermometer is much smaller and more delicate than the rest, Viz. the Farenheit, the Centigrade and the Reumer. It is a small part of the Farenheit thermometer with markings for recording temperatures from 95° to 110°F. Why? (These are the lowest and the highest temperatures compatible with human life). Note these graduations and see that each degree is divided into five equal parts. Also note that opposite 98·4° there is an arrow mark. This is the normal temperature of human beings in health.

Note the different parts of the thermometer:-

(1) the bulb containing mercury, and

(2) the stem bearing the above-noted graduations. From the bulb leads a very fine capillary tube in which the mercury rises when the bulb gets warm. Note the constriction a little beyond the bulb in this capillary tube which does not let the mercury fall automatically once it has gone up due to the expansion of the mercury by heat. Explain the usefulness of this constriction. In order to bring it down you have to jerk the thermometer once or twice by holding the stem. Be careful in this procedure that the bulb does not touch anything otherwise it will break. Note that this constriction is absent in your laboratory thermometers and so their temperatures fall automatically. See that on the stem is also written ½ minute 1 minute, 2 minutes, or 5 minutes, for

which the thermometer must be used to show correct temperature. This themometer is also called a ***Doctor's Thermometer.***

DIRECTIONS FOR USE.

(1) Take it out from its case gently and be careful that it may not fall.

(2) Wash it with cold water or some weak antiseptic lotion e.g. 1 in 40 Carbolic Lotion or 1 in 2000 mercury lotion etc. before and after use.

(3) Then read it and see, that the mercury is below 95° or so. If it is above this, give it a few jerks by holding the stem.

N.B. It is not necessary to bring the level down to 95°. If it remains at 96° or so, it is all right.

(4) Then place the thermometer in the armpit or groin or in the mouth under the tongue. If it is to be placed in the armpit or groin remember to clean the place with handkerchief to remove sweat. Also see that the bulb is actually in contact with the skin all round. The clothes should not intervene. If it is to be placed in the mouth, it should be underneath the tongue and the mouth should be closed and the thermometer be held by the lips and not by the teeth. The breathing should be entirely done through the nose.

(5) Keep it there for a little longer period than what is written on the stem.

(6) Then take it out and read. Be careful not to touch the bulb or to hold it by the bulb in order to read. Hold it horizontally (not vertically) by catching the thermometer a

little above the bulb between the thumb and first two fingers of the left hand and the other end of the stem between the thumb and first two fingers of the right hand with the graduated side facing you. Rotate it a little to and fro, and you will see a white line in continuation with the bulb going some distance into the stem. Mark its upper-most end and read it.

(7) Then clean the thermometer and replace it in the case ***gently with bulb downwards.***

N.B. **Normal temperature of human beings is generally 97°, to 98° in axilla or groin and 97·6° to 98·4° or even 99° in the mouth.**

Sketch the Clinical thermometer and take your temperature in the mouth and record.

USE OF A LACTOMETER.

Get a lactometer and note its various parts, viz. the rounded bulb filled with lead-shots or mercury, the second elongated bulb above the first one which is empty, and a long tube—the *stem*—which is uppermost and is graduated, bearing the letter M lower-most at the bottom and W at its upper end. The distance between M and W is differently divided in different instruments into 4, 5, or 10 divisions, but generally into 4 divisions.

If it is placed in pure milk it sinks to the mark M and if in water, it sinks to the mark W. The temperature of the fluid to be tested should be 15° C or 60° F. to get correct results, as these instruments are generally so constructed.

Now if you place it in a specimen of milk in which it sinks to the mark 3 i.e. one division above M is in the milk and three are outside; it denotes that the specimen contains one part of water and 3 parts of milk. If it stands at the mark 2 i.e. two divisions above M are in the milk and the remaining two divisions are above it, the milk contains equal parts of milk and water.

Test the specimens of milk provided in tubes A, B and C to find out the % of water in each. Also test some strong watery solutions of sodium chloride (common salt) and ammonium chloride.

We conclude from the above that :—

(1) Water being lighter than milk makes the lactometer to sink more, so that when some water is present in milk it sinks more than in pure milk.

(2) Salts (like sodium chloride and ammonium chloride) make the water heavier as more of the stem floats than in pure water.

The teacher here should explain to the class those factors which increase the specific gravity of the milk and those factors which decrease the specific gravity of the milk.

Remember that :—

(1) Water in milk makes it sink more i.e. lowers the specific gravity.

(2) Fat in milk makes it sink more i. e. lowers the specific gravity or brings it nearer to that of water, because fat is lighter than water.

(3) Milk sugar and salts in milk make it float more i.e. increase the specific gravity.

N.B. (1) This instrument gives us no exact idea of the purity of milk. It only tells us how much water has been mixed in pure milk.

(2) Even pure milk from different animals e. g. cow, goat, or buffalo, will differ when tested by it. Even the milk which is rich in fats may show lesser specific gravity and so sink more.

(3) Milk from which fat has been removed and water added may appear pure milk and stand at M if tested by this instrument.

(4) This instrument is only to test the specific gravity (density) of milk.

(5) Purity of milk can be determined by the specific gravity and the fat percentage.

NOTE :—Specific gravity of pure milk is from 1027 to 1034. The amount of cream in pure milk is from 8 to 11 % as tested by the creamometer.

Sketch this instrument.

APPEARANCE OF A SOLUTION OF THE WHITE OF AN EGG WHEN BOILED.

Break a hen's egg by giving a gentle tap on the table and remove a little of the broken shell. Let the white of the egg flow through this hole in a porcelain dish. Be careful that the yolk is not mixed with the white. Beat this white with a spoon so as to make it thoroughly homogeneous. Divide it into 2 equal parts in 2 dishes. Add to one part about 10 parts of water beating all the time. You may make this watery solution in a flask. Note that the solution is slightly opalescent.

Expt. 1 Take a little of this solution in a test tube and boil it. Note it becomes more opalescent. It does not coagulate. Add a little acetic acid to it, a thick co-agulum forms.

Expt. 2 Take the second part which is the undiluted white of an egg and boil it. Note that it co-agulates.

Conclusion. The white of an egg coagulates on boiling while its solution does not. But the solution becomes more opalescent on boiling which coagulates on acidulation.

Write in your own words as to how you carry out this experiment.

IODINE TEST FOR STARCH.

Experiment:—Boil a little starch from potato or wheat flour in a test-tube in a little distilled water. Let it cool, and then add a drop or two of a weak solution of iodine (2 to 3 drops of tincture iodine in about 10 c.c. of distilled water).

Note that the colour of the solution becomes intense blue. Boil this again and see that the blue colour disappears. Let it cool and the blue colour reappears.

Write out the whole procedure in your own words.

GENERAL PROCESS OF GASTRIC DIGESTION.

Before proceeding with this experiment the teacher should tell the composition and action of gastric juice to the students.

Things required for the experiment:—Berger's Liquor Pepticus (in place of Pepsin), Berger's Rennet (in place of Rennin of Gastric juice), Hydrochloric acid, distilled water, and the white of an egg, (protein to be acted upon), glass marking pencil, water bath, test tubes, porcelain dishes, rack, centigrade thermometer, spirit lamp, burette stand, some calcium chloride solution, some milk and a match-box.

There are two ferments in the gastric juice viz. pepsin and rennin, so we may do this experiment in two stages, viz; action of pepsin on protein, and action of renin on milk.

Experiment I. Make an artificial gastric juice as follows:—

To a little liquor pepticus add excess of (about 10 times) diluted hydrochloric acid (1 in 500).

In a procelain dish boil a little white of an egg and keep it for the experiment.

Take four test tubes and mark them, 1, 2, 3, and 4.

In No. 1 put some dilute hydrochloric acid.

In No. 2 put a little liquor pepeticus and 5 to 6 times distilled water.

In Nos. 3 and 4 put some artificial gastric juice. Then boil the tube No. 3 and let it cool. Now put in all the four test tubes, equal parts of the boiled white of egg and place them in a water-bath at 40° centigrade. Keep the

temperature constant. Let these tubes remain there from 30 to 45 minutes. After that take them out of the bath and note that:—

There is no change in 1, 2, and 3, i.e. the co-agulated egg-white is the same and not dissolved.

In No. 4 it has all dissolved.

We infer from the above that:—

(*a*) *Hydrochloric acid and pepsin alone do not action the proteins.*

(*b*) *Boiling destroys the pepsin.*

(*c*) *The hydrochloric acid and pepsin together act on proteins.*

Experiment II. As before take four test tubes and mark them Nos. 1, 2, 3, and 4. In all these put some Benger's Rennet.

Pour some boiled milk which has been cooled in Nos. 1, 2, and 3, and a little unboiled milk in No. 4. In No. 2, also add some calcium chloride solution. After that boil the tube No. 3 and let it stand to cool and then add to this (No. 3) some calcium chloride solution. Next place all the test tubes in water-bath at 40° C for 30 to 45 minutes.

After that take them out and note that in Nos. 1 and 3 there is no change, while milk is curdled in No. 2 and 4.

Tube No. 1	Contains	Rennet + Boiled cooled milk	= No change.
Tube No. 2	,,	Rennet + Boiled cooled milk + Calcium Chloride	= Curdled
Tube No. 3	,,	(Rennet + Boiled cooled milk) both then Boiled + Calcium chloride	= No change.
Tube No. 4	,,	Rennet + Unboiled milk	= Curdled.

We infer from the above that:—

(*a*) Rennet co-agulates unboiled milk and has no action on boiled milk (from Nos. 1 and 4).

(*b*) Rennet is destroyed by the action of heat (from No. 3).

(*c*) Calcium chloride helps the co-agulation of boiled milk (from No. 2).

Re-write shortly the two experiments in tabular form with results.

SIMPLE TEST FOR SHORT AND LONG SIGHT.

Get a Snellen's test chart from an optician and see that the letters in the chart are written in various sizes which go on decreasing as we read downward. Above each line we find written D=some number in feet or metres in small print e. g. (highest is D= 60 meters and lowest is D=6M or 20 feet). This lowest number indicates the distance at which a normal person can read that line with each eye separately. So this means that the lowest line should be read clearly with each eye separately at a distance of six metres or 20 feet.

(The teacher should explain the principle on which the chart is made, to the boys).

Short Sightedness (Myopia). Do the experiment like this.

1. Hang the chart in good light at the height of about 6 to 7 feet (i. e. the lowest line of the chart (D=6M) should be nearly at the same level as the eyes of the person whose sight is to be tested).

2. Make the person to be examined stand in front of the chart with back towards the light at the distance of six meters or 20 feet from the chart.

3. Ask him to close his left eye with the cup of his left hand. His eye should be open behind the cup which only does not allow him to see.

   (The teacher may do it with his own hand).

4. Tell him to read from above downwards.

If he can read all the letters of the chart with each eye separately, his eye-sight is either normal or he is long-sighted (Hypermetropic). If he cannot read all letters he is short-sighted (Myopic) and should go to an eye-specialist for spectacles.

Long Sightedness (Hypermetroia)—In the above experiment when he can read all the letters on the chart correctly and separately with each eye, place a low convex lens (+I. O D.) before his eye and let him read. If the letters do not become dim, he is long sighted.

Test your own sight and record results.

DEMONSTRATION OF THE EXISTENCE OF BLIND SPOT.

On the opposite page of your note-book make two small figures, a cross to your left and a circle to your right about 3" apart from each other. Hold the note book about 10 to 12 inches away from your eyes with your right hand. Close your left eye with your left hand and fix your right eye at the cross. While you are looking only at the cross with your right eye you are still seeing the circle. Then bring the note book nearer towards your eye. Keep the right eye looking fixedly at the cross. At a certain distance the circle disappears. This is the place when the image of the circle falls on the Blind Spot. Move the book still nearer to the eye, the circle re-appears.

Repeat the same experiment with the right eye closed and left eye looking on the circle. The same phenomena will be noted.

Explanation:—When we look at a thing directly its image falls on the yellow spot, the place of acutest vision, so that the thing is seen clearly, (Direct Vision); while the image of other things all round are falling on the rest of the retina, so they are indistinct (Indirect Vision). At a certain place the image of the object seen by indirect Vision falls on the blind spot, (the place where the optic nerve enters the eye-ball and which is devoid of sensitive light), and so there it is not seen. When we move it still nearer its image again falls on the retina and hence is again seen.

Make a diagram on the opposite page and write the experiment in your own words with its full explanation.

FORMATION OF A REAL IMAGE BY A CONVEX LENS.

Apparatus:—A candle, three or four lenses of different curvatures, a screen all fixed on stand, and a match box.

Expt. 1. Place a lens of medium curvature, the screen and the candle in a straight line on the table in such a way that the lens is in the centre and the screen and the candle are on either side. Adjust their heights so that all of them are in the same level. Then light the candle. By moving the screen and the candle to and fro you will get an inverted image of the candle on the screen. Draw a diagram of this showing the path of rays in your note book, on the opposite page.

Expt. 2. Move the candle away from the lens and note that its image on the screen gets blurred or lost. Remove the lens and place instead another lens of lesser curvature and you will again see the clear inverted image on the screen.

Expt. 3. Next bring the candle much nearer to the lens, the image again disappears. Now change the lens for the lens of higher curvature and the image again appears.

We infer from the above that:—

(*a*) the nearer the object to the lens the greater should be the curvature of the lens to form a clear image on the fixed screen.

(*b*) and the farther the object from the lens, the lesser should be the curvature of the lens to form a clear image on the fixed screen.

In the eye too, the distance between the screen (retina) and the lens (optical lens) is fixed, as it was in the above experiment. To form images of objects situated at different distances from the eye, the lens keeps on changing its curvature i.e. becomes thiker when we see a near thing and becomes thinner when we see a far off thing. This power which the lens possesses is known as ***Accommodation.***

Make three diagrams showing the path of rays in the above three experiments.

Expt. 4. Set the things as in Expt. 1 to get a real inverted image with a medium convex lens. Move the candle ***away from*** the lens. Note its image gets blurred which can be made distinct by moving the screen ***towards*** the lens. Similarly move the candle ***towards*** the lens, its image gets blurred which can be made distinct again by moving the screen ***away.***

We infer from the Expt. 4 that :—

(*a*) the nearer the object is to the lens, the greater the distance between the lens and the screen.

(*b*) and the farther the object is from the lens, the lesser the distance between the lens and the screen.

SIMPLE TESTS FOR HEARING.

Let the person whose hearing is to be tested sit on a stool and then blind-fold him preserve with a finger. Take a watch with a good tick and keep it at distance of about two feet from his right ear. Ask him if he hears the ticking sound of the watch. He will say "No". Then bring the watch slowly nearer towards his ear and let him say "Yes" immediately he begains to listen. Measure the distance of the watch from the ear at this point.

N. B. In the above experiment the lett ear should be firmly pressed by the thumb so that he may not listen with that ear. Repeat the same experiment with left ear and record results.

Next do the same experiment on a person who is known to have normal hearing power, and record the result. If the distances are the same in both the persons, then the persons examined first has normal hearing. If he can hear from a shorter distance, his hearing power is defective.

N.B. (This is not a very reliable and accurate test.)

Tell the boys to do the experiment in batches of two, upon each.

DEMONSTRATION OF A REFLEX ACT.

(1) Bring your finger near the eye of the person who is not aware of it as if you are going to strike. You will notice that he winks his eye. This is known as ***Winking Reflex.***

(2) Ask a boy to sit at the edge of a table. Place your left hand under his right thigh by standing towards his right and ask the student to place all the weight of the thigh on your hand and let him hang his leg loose. Then ask him to close his eyes. Now give a sharp tap at the patellar ligament with the inner margin of your right hand. You will notice that the boy at once jerks his leg forwards. This is called the ***Knee-jerk.*** If the tap is given at a wrong place nothing will happen.

(3) If you scratch with a pin the sole of a sleeping person he withdraws his leg. This is a Reflex Action as he is not aware of it when awakened.

N. B. The teacher here should explain to the class these reflexes with experiments. Draw a diagram on the opposite page of the reflex of experiment No. 3.

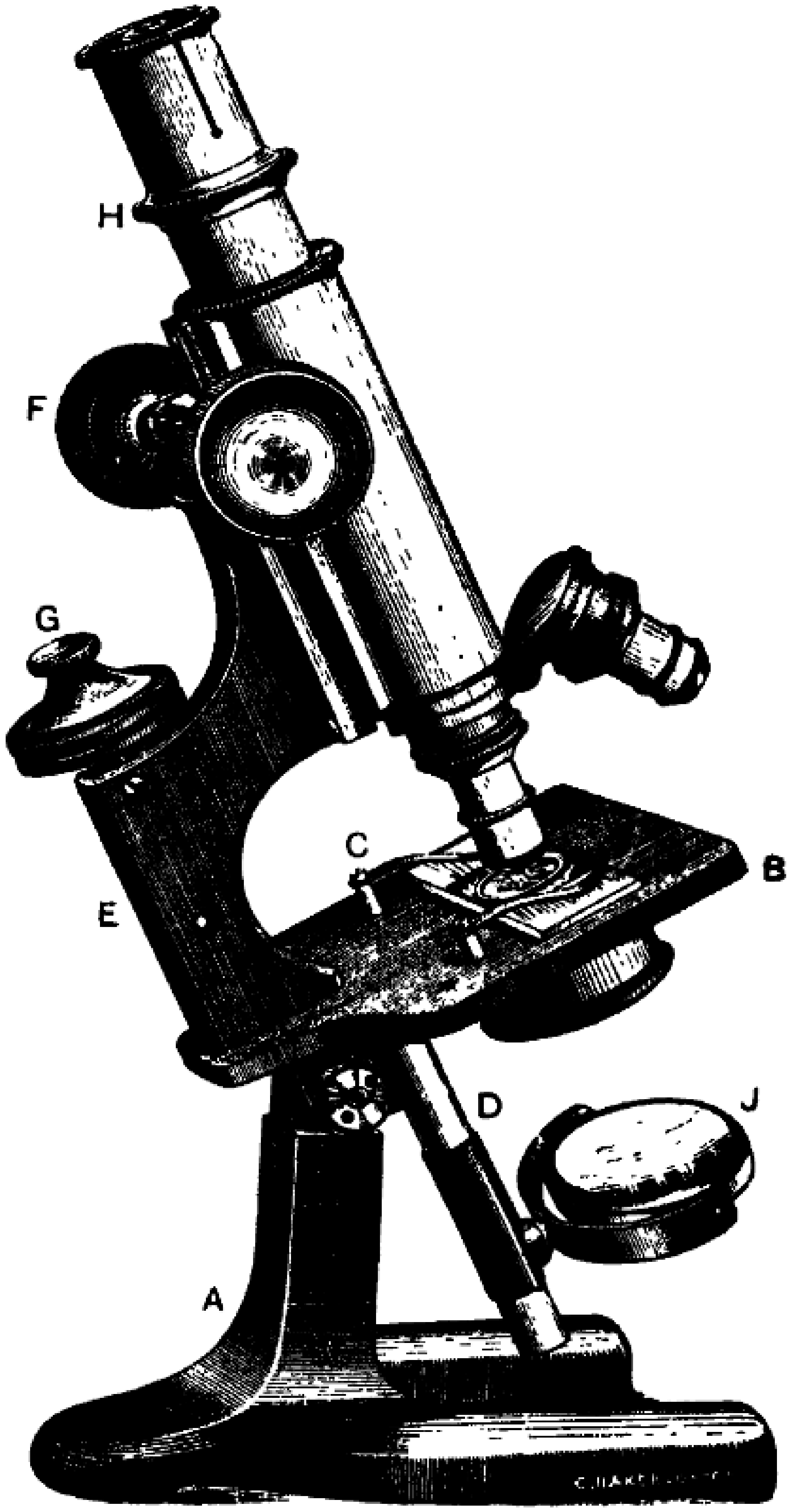
PARTS AND WORKING OF A MICROSCOPE.

Look carefully at the microscope put before you on the table. Note the following parts :—

Body Tube*,** a long cylindrical tube in which there is another tube called the ***Draw tube*.** (H.) On the upper end of the draw tube is placed the ***Eye-pice or the Ocoular*.** To the lower end of the body tube are fixed two circular discs to which the ***Objectives are attached. The draw tube can be raised or lowered, thus changing the position of the eye pice above. Objectives are of two kinds, high power (1/6″=4 mm) and low power (2/3″=16 mm). Also note the ***Stage*** (C) on which the slide is put for examination. The slide is illuminated by light passing through the hole in the stage reflected by a ***concave*** or a ***plan mirror*** (J). (***Plane mirror*** is only used when we use the ***condensor***). Below the stage one may notice a ***Diaphragm*** by which we can regulate the amount of light, and noted passing to the slide as we desire. Some microscopes are also provided with a big lens placed just beneath the stage called ***Condensor*** which can be so shifted that it may be brought under the stage or moved away.

(Some instruments are also fitted witd a mechanical stage, a contrivance for moviug the side to and fro).

All these parts are attached to the ***Arm*** (E) which in its turn is resting on the ***Base*** (A). Also note the two screw-like parts called the ***Coarse*** (F) and the ***Fine*** (G) ***Adjustment Screws*** attached to the upper part of the Arm.



COMPOUND MICROSCOPE [See description on page 72]

A=base or stand : **B**=diaphragm : **C**=stage;

D=stand for reflecting mirror : **E**=arm ; **F**=rough adjustment screw :

G=fine adjustment screw: **H**=draw tube; **J**=reflecting mirror.

How to use it:-

Put the slide on the stage and rotate the low power in such a way that the low power, body tube, and the eye piece are in one line. Now look through the eye-piece and adjust the concave mirror to get the best illumination. Bring the low power quite near to the slide and with the help of the coarse adjustment screw move it upwords slowly so that you may see the object on the slide. Then, if necessary, make it more clear and distinct by fine adjustment screw to suit your sight.

For using the high power, rotate the low power, when adjusted, away, and bring the high power in its place. Fix it correctly with fine adjustment screw.

Precautions:-

(1) Be careful in handling the instrument as it is very delicate and costly.

(2) Always adjust the low power first and move it ***always from below upwards otherwise*** you may break the slide or the objective if you do it from above downwards.

The student should cultivate this habit from the very beginning. Then adjust high power.

(3) If you find dust deposited on the eye-piece or concave mirror or on the objective, clean it with a soft muslin or silk cloth. Do not wash with water etc.

(4) When replacing the miscroscope back into its box after use, you should bring down the low power as low down and near the stage as possible.

MICROSCOPIC EXAMINATION OF BLOOD, BONE & MUSCLE.

Blood:—Take hold of a student and wipe his left hand's finger with methylated spirit. Let it dry. Then warm the point of a pin on the flame of a candle. Prick the finger sharply with it. Immediately a small drop of blood appears. Take it on a clean slide for examination. One another slide take another drop of blood and with the help of the edge of the first slide draw it into a thin and even film. Put them under the miscroscope. Now in the drop of blood you will notice a number of round flattened discs called ***Blood Corpuscles or Cells*** floating in a clear fluid called ***Plasma.*** Now in the thin film you will notice (or better still in a special stained slide) that corpuselcs are of two kinds.

(1) Red cells appearing as small, circular, flattened, biconcave, non-nucleated discs which are very many in number; called ***Red Blood Corpuscles*** or ***cells*** and

(2) White cells, irregularly shaped, comparatively larger, and having one or more nuclei, much fewer in number and have different shapes and appear colourless (blue in the stained slide). These are termed ***Leucocytes*** or ***White Blood Cells*** or ***Corpuscles.***

N. B. (i) The blood appears red due to the abundance of the red cells over the white. (600 : 1)

(ii) In an unstained slide it is rather difficult to see the white cells as they are colourless.

(*iii*) R. B. C. of all muscles are non-nucleated, while these are nucleated in cold blooded animals, e.g. frog, fish etc.

Bone : Get two prepared slides of bone, one of cross-section and the other of longitudinal section and see them under the microscope.

(*a*) ***Cross Section of bone.*** In this you will see a cob-web appearance i.e. it will be seen to be mapped out into a number of circular district. In this centre of each distinct there you see a big dark spot which is the opening of a small canal in the bone which is called the ***Haversion Canal.*** Around this you see concentric rings which are really much smaller canals than the above called the ***Canaliculi*** in the bone. On these concentric rings you may see small spots resembling knots, from which radiate the small lines (Canaliculi) in all directions. These small spots are little spaces in the bone which lodge the ***bone Cells*** and these radiating lines are really canals for small blood vessels. The Haversion canals also contain slightly bigger blood vessals for nourishing the bone during life. The whole thing appears like a net-work.

(*b*) ***Longitudinal Section.*** In this Haversion canals are not seen as big round dark spots but they look like long empty spaces which branch and communicate at short intervals. One can certainly see the bone calls and the canaliculi as above.

Draw diagrams of what you see.

Muscle : Get 4 prepared slides of muscles, viz., Longitudinal Sections of :—

(1) Voluntary
(2) In-voluntary muscles
(3) Heart muscle
(4) Transverse section of any of these muscles.

(*a*) ***Longitudinal section of striped muscle.*** You see long red muscle fibres which appear to be made up of alternate dark and light bands or stripes which give the name. Sketch this.

(*b*) ***Longitudinal section of unstriped muscle.*** You will note spindle shaped tapering fibres which have not got any stripes or bands, but they have got elongated nuclei (c.f. striped muscles fibres).

(*c*) ***Longitudinal section of heart muscle.*** Here you will see quadrilateral short and thick fibres which also appear to be striped. Sketch this.

(*d*) ***Transverse section of any muscle.*** One may see red areas separated by whitish lines representing the ends of the fibres.

Write in your own words the differences by which you can recognize longitudinal sections of (*i*) unstriped muscle, (*ii*) heart muscle and (*iii*) striped muscle.

MICROSCOPIC APPEARANCE OF MILK & STARCH GRAINS FROM POTATO

(1) ***Milk.*** Take a clean glass slide and with a glass rod dipped in milk put a tiny droplet ou it. Cover it gently with a cover glass. Then examine it under the microscope. Note that a large number of round globules of different sizes float in an opaque fluid. These are the fat globules. The richer the milk the bigger and the more numerous are the fat globules. (C. F. the microscopic appearance of blood).

Next examine a drop of buttermilk and you will note that the globules are very few and smaller in size. Remember fat is present in milk as an emulsion.

Draw what you see.

Why is milk called a perfect food? Give the composition of milk.

(2) ***Strach grains from potato.*** Cut a potato and scrape the cut surface a little with the handle of a clean scalpel. Place some of this scraping on a clean glass slide; put a drop of distilled water, mix and put a cover glass gently. Then examine it under the microscope. You will see a number of starch grains with oval concentric rings round a point (Hilum) which represents the centre and is a little to one side. The appearance is very characteristic.

Sketch what you see.

IDENTIFICATION OF LARVA AND ADULT STAGES OF CLUEX AND ANOPHELES AND THE FOLLOWING OTHER DISEASE CARRYING INSECTS . ...FLEA, SANDFLY AND HOUSE FLY.

1. Culex and Anopheles Larvae.

Mosquitoes breed in water near the bank. So you can easily get both of these kinds of larvae in a collection of water, e.g. a pond, cesspool or even an earthen pot etc., in August, September and October. Catch the larvae by dipping a dish in water containing them and then suddenly bringing the dish out. Pour this water of the dish in a trough containing some water and see how they float.

Note each larvae consists of a head, a narrow neck and a segmented body.

You can distinguish the culex larvae from the anopheles larvae by the way in which they float in water.

The ***culex larva*** floats in water with its head downwards and the body is at various angles to the surface of the water; while the ***anopheles larvae*** floats with its body lying in horizontal direction and parallel to the surface of water. This difference is due to the fact that the former has a breathing tube while the latter is devoid of it.

Sketch them as they float in water.

Anopheles And Culex Adults.

Catch some mosquitoes from corners of dark deserted houses or mud huts, or behind curtains or clothes hanging on pegs which have not been disturbed for some days, in the months of September, October and

November (after the rainy season). The way to catch a mosquito is to place an inverted test-tube or cylinder suddenly at the place where it is sitting.

Identify them by the following points:—

(1) ***Anopheles*** sits on a plane surface e.g. floor, wall, table etc., with its quite straight body making an angle with the surface (and not parallel), and the hinder legs are beneath the abdomen. ***Culex*** sits on a plane surface with its body slightly bent on itself and more or less parallel to the surface, and the legs stick out above the abdomen.

(2) In ***anopheles*** wings and legs are beautifully spotted while in ***culex*** they are clean and unspotted.

(3) Proboscis (biting instrument) and the head is much bigger in anopheles than in the culices.

Sketch them as they are seen sitting on a plane surface. Name the diseases conveyed by them.

Flea. Get one from an infected dog (dogs have generally fleas on their bodies). Kill it with chloroform and place it on a clean slide and moisten it with a drop of normal saline or distilled water. Either see it with a lens or examine it under the low power of a microscope.

Note the following parts:—

(1) ***Head*** to which is attached the blood-sucking apparatus,

(2) a narrow ***neck,***

(3) ***thorax*** which is flattened from side to side and to which six pairs of legs are attached and

(4) the *abdomen*. The special point about it is that the whole body generally and the thorax and the legs specially are covered all over with bristles or scales.

Sketch it. How is it dangerous to man?

Sand-Fly. These are generally found in or near bath rooms, near the floor, under bricks and stones, or in other damp places. Generally speaking they breed in places where organic matter is undergoing decomposition. So they can be easily found in the drain and back of cook houses. It is very difficult to catch one as it is very restless. It is a small insect but is stoutly built and has large wings. They have a dark colour and so are also called ***black flies***. Its larvae is aquatic.

Examine a mounted sand-fly under the low power of a microscope. See its different parts viz; head, neck, thorax, abdomen and large wings. Note that there are no scales or bristles on its body or legs (unlike flea). The wings are thin and transparent. Sketch it. What are the diseases conveyed by it?

House-fly. Catch a common house-fly and note that it has a ***head, a neck, a thorax*** and a segmented ***abdomen***. Examine the head under the microscope, and see that it has a suctorial, a mouth with two jaws and two prominent eyes. The neck is very small. Thorax has got six legs and the wings attached to it. The latter are beautifully spotted.

The larvae of house-fly are called ***Maggots***. They are often found in dirty wounds, decomposing refuse and decaying heaps. They are whitish and elongated, and have segmented bodies.

Draw a common house-fly and its maggot, if available. What are the diseases conveyed by the house-fly.

IDENTIFICATION AND MODE OF EMPLOYMENT OF COMMONER DISINFECTANTS.

Disinfectants are substances which destroy germs e.g. corrosive sublimate. They are divided into three classes:—

(1) Natural disinfectants, e.g. sun-light; fresh air; etc.

(2) Physical disinfectants, e.g. fire; boiling; hot air; steam; etc.

(3) Chemical disinfectants, e.g. lime; corrosive sublimate; etc. Here we are chiefly concerned with these. These may be:

(A) solid, (B) liquid, or (C) gaseous.

A. Solid Disinfectants:— Common ones are:-

1. SOAP. This is a thing of common use. It is either hard or soft. Hard soap is prepared with caustic soda and soft one is prepared with caustic potash. It is used for cleaning soiled linen and washing hands etc.

2. LIME(CaO). It is prepared by burning lime-stone ($CaCO_3$) in kilns. It forms whitish masses which turn into powder when water is poured on them with the evolution of great heat. This powder is known as ***slaked-lime***, $CaO+H_2O=Ca(OH)_2$ which is used for white- washing the walls. Lime is also used for disinfecting wells. Remember that it becomes useless if stored for some time, as it is changed into chalk which is inert.

3. BLEACHING POWDER OR CHLORIDE OF LIME.

It is a dull white powder which smells heavily of chlorine. It is chiefly used for bleaching vegetable colours or disinfecting drinking water. On long keeping chlorine gas goes oft leaving the powder useless.

B. Liquid Disinfectants:— These are mostly used out of the 3 kinds. The most important of them are:—

1. PER-CHLORIDE OF MERCURY OR COROSSIVE SUBLIMATE ($HgCl_2$). It occurs as heavy whitish or colourless crystalline lumps. It is one of the most powerful disinfectants and forms a colourless and odourless solution. It is an ext-

remely poisonous substance. It is soluble in water and is used in strength of 1 in 500 for disinfecting clothes and patients' dis-charges etc., 1 in 1000 for washing hands; 1 in 2000 for washing small and single wound and 1 in 5000 for washing a large wound or many wounds and when repeated washing is required. Its use is only limited due to the following points:—

(1) It corrodes instruments,

(2) it co-agulates albumen. So its power of penetrating into the interior of the organic matter is much limited unless some acid is added to it, and

(3) it makes a very poisonous and colourless solution with water.

Its special action is Antiparasitic i.e. killing parasites, hence it is used for killing lice on the head and body and to cure ring-worm disease.

N. B. It is generally sold in the market in the form of tablets, coloured blue to make the lotion coloured in order to recognize it from water.

2. CYANIDIE OF MERCURY (Hg CN). This is even a greater poision than the perchloride of mercury but is a very good antisepic. It is hardly ever used for disinfection as it is very dear and highly poisonous.

3. CARBOLIC ACID or PHENOL. It is one of the most commonly used disinfectants. It occurs in colourless, deliquescent, needle-like crystals which have got a characteristic odour. It readily absorbs moisture from the atmosphere and turns into a pinkish liquid. It is generally used as a watery solution in the strength of 1 in 20 for disinfecting clothes and discharges from Cholera Typhoid, Dysentery and Diarrhoea patients, and in 1-40 strength for washing wounds and hands etc. To disinfect stools, urine, etc. mix with equal amounts of 1 in 20 carbolic lotion. Infected articles like clothes etc. should be placed in 1 in 20 carbolic lotion for at least one hour before giving to the dhobi.

It is also used as a preservative in 1 in 200 solution. It is an antiseptic as well as a deodorant. When accidently strong acid touches the skin, it becomes white called carbolic acid burn.

4. SAPONIFIED CRESOL. It is one of the coal-tar derivatives and occurs as a dark, thick and viscid liquid. It is less poisonous and cheaper than carbolic acid. It is equally efficacious. So it is more widely used. It changes its colour to brown on keeping.

It is used as an emulsion in water for disinfecting drains, soiled or infected clothes etc. It is also used as gas (see below). It does not bleach colour or corrode metlas.

It is a very good disinfectant, parasiticide and beodorant.

5. PHENYLE. It forms a milky solution in water with a characteristic odour. It occurs as a dark thick liquid. As a disinfectant it is quite weak but is largely used as a deodorant for drains latrines, urinals etc.

6. FORMALINE. It contains formaldehyde in solution in water (see below). It has got a characteristic pungent odour but no colour.. 10% solution in water makes a very good disinfectant. It makes skin rough and hard. It is used as a preservative for biological specimens and tissues like, brain heart, etc.

7. POTASSIUM PERMANGANATE $(KMnO)_4$. It exists as dark purple, fine slender, crystals which are easily soluble in water giving it a pink or purple red colour which soon turns to dark brown. It is a weak germicide but is a good deodorant for drains, mouth wash etc. It is largely useed in cholera days to kill cholera germs in drinking wells. As a disinfectant it is used as 5% solution. There are certain drawbacks in it, viz.:—

(1) It stains linen.

(2) It is quite dear and cannot be used on a large scale.

(3) It is unstable as oxygen gas is easily liberated when it comes in contact with the organic matter in which the germs generally live.

Write the method of disinfecting an ordinary sized well with potassium permanganate.

C. **Gaseous Disinfectants:**—Those which are used chiefly as gas without caring whether they exist as solid or liquid.

1. SULPHUR DI-OXIDE ($S+O_2=SO_2$). It is prepared by burning sulphur, which exists as yellow gritty powder without any taste. When we burn sulphur, sulphur di-oxide is produced and this gas has got a great affinity for moisture with which it combines to produce sulphurous acid ($SO_2+H_2O=H_2SO_3$) which is a great reducing agent. This acid at once draws oxygen ($H_2SO_3+O=H_2SO_4$) from the body of germs and thus kills them on coming in contact with them. It has a pungent odour and has got a great penetrating power. It is used largely for disinfecting houses after any infectious disease and the method is as follows:—

Close all the doors, windows, ventilators, the skylights of the room to be disinfected. Let only one door remain open. Then close all the crevices and chinks in the doors etc. by pasting paper so that sulphur di-oxide may not be allowed to escape out. The things to be disinfected should be damped before hand. Burn enough charcoal in the room to keep burning for two hours. Put sulphur in some metallic vessel. For 1000 c. ft. capacity 2 pounds of sulphur are enough. Put this vessel on the fire. Also put a vessel containing water on the fire near the sulphur so that water may also evaporate simultaneously. Get out of the room at once and close the door behind. Let it burn for two hours. After that open all the doors and windows. Be careful not to occupy the room till at least six hours after disinfection, and during this time all the doors and windows should remain open. It

is wise to burn the required amount of sulphur in three or four places in the room and it should be burnt as high as possible.

2. FORMALDEHYDE. It is a gas with very pungent odour. It is produced by pouring formaline over potassium permanganate or by heating formaline under pressure. 10 ounces of formaline when poured on 5 ounces of potassium permanganante produce formaldehyde enough to disinfect 1000 c. ft. and six hours are necessary for it. It is a very powerful disinfectant and deodorant. It does not bleach colour or corrode metallic vessels except iron and is much stronger than sulphur dioxide. So it has largely replaced the latter. It is quite cheap. The only defect that it has got is that it is very irritating to the eyes and the throat. Remember that it is non-poisonous to man.

3. CHLORINE. It is a greenish yellow gas with a peculiar pungent odour which makes it easily recognizable. It is soluble in water and can be produced by pouring strong hydrochloric acid on bleaching powder. It needs moisture to act as a disinfectant and being a heavy gas difuses badly. It bleaches colours more readily than sulphur dieoxide. It is more expensive and less convenient to use. For 1000 c. ft. space 2 pounds of bleaching powder acted upon by 1 pound of commercial hydrocloric acid are required. It corrodes metals and so metal-fittings should be removed from the rooms, when disinfecting with this gas. It is generally used for disinfecting drinking water on a large scale and for bleaching colours.

4. CRESOL or CREOSOL. As explained above. it is a coal-tar derivative. It is used as gas for dis infecting rooms in plague days. For this purpose 2 ounces of cresol are either heated slowly on fire or poured on smouldering cow-dung cakes. This quantity is sufficient for 1000, c. ft. of space.
Its advantages are:—

(1) It has no action on metals.

(2) It does not irritate or act as poison to higher forms of life.

(3) It is extremely efficious for disinfecting houses.

(4) It is quite cheap.

For disinfecting rooms same precautions are to be taken as in sulphur dioxide.

MICROSCOPIC APPEARANCE OF COTTON. WOOLEN, & SILK FIBRES, AND OF ADMIXTURES.

COTTON. Examine a cotton thread and note that it has a characteristic appearance. It looks like a ribbon or a flat tape which is twisted on itself at regular intervals. The interior of the fibre is often obliterated, and may contain some extractive matter, and its borders are a little thickened. Make a sketch.

WOOL. Examine a fresh fibre of wool under the microscope and note its characteristic appearance. It looks like a hair with scales overlapping each other on the margins and giving a wavy appearance to the surface of the fibre. Just like hair they appear as cylinders with some extractive matter in the central canal and little serration or dentitions on the margins. This characteristic appearance is only found in fresh fibres. When old and worn-out the wavy line on the fibres disappears, and the serrations too, are lost on the margins. Sketch the appearance of fresh and old fibres.

SILK. Examine a silk fibre under the microscope. Note that the fibres are made up of regular cylinders and present little swellings at regular intervals. Also note that their margins are well-marked, homogenious, and transparent. When old and worn-out, there occurs a splitting up along its axis. Draw it as seen under the microscope.

(vi) ADMIXTURE. Mix three fibres together, one cotton, one woollen and one silk. Put them on a clean glass slide and moisten them with a drop

of distilled water and cover them with a cover-slip. Then examine it under the microscope. You can then easily distinguish all the three kinds of fibres by their characteristics given above, viz:-

(1) Cotton appearing as a flat ribbon, twisted upon itself;

(2) silk as regular transparent cylinders with swellings here and there on borders;

(3) wool as a cylinder with dentated margins and its central canal generally containing extractive matter. The whole fibre shows above it some wavy lines like a screw. Draw a diagram of the admixture and lable the different fibres.

N B. The teacher should make different mixtures of silk and wool, silk and cotton, and cotton and wool and should ask the students to examine them.

Draw diagrams of all these. Give the use of the microscopic examination of the various fibres and admixtures.

FILTRATION

This is the process by which impure drink water is rendered pure and fit for drinking.

Three kinds of filters are generally used.

(1) Pasteur-Chamberland Filter.
(2) Berkfeld Filter, and
(3) "A Poor Man's Filter."

1. Pasteur-Chamberland Filter. Note that it consists of two vessels, the outer being made of glazed porcelain. Also note that on the upper end it has got a pipe by which it it connected to an ordinary tap. Water remains in this vessel under pressure.

The second vessel lies inside the first and is made up of a special porous clay through which water of the outer vessel is filtered into its inside. Through these pores even the finest suspended impurities e. g. minute bacteria, can not pass.

Also note that the inner tube can be removed, cleaned and dried.

Thre is an arrangement (exit) for removing water from the inner tube.

2. **Berkfeld Filter.** It is nearly the same as the first one with the difference that water is poured in the inner tube by the tap and it filters through the porous tube into the outer vessel from where water comes out for use.

Draw any filter labelling the two vessels. What are the precautions to be taken in using this filter?

3. **"A Poor Man's Filter":**—Take three earthen Gharas. Into the bottom of each make a small hold with a file. Place these three Gharas one above each other on a tripod. Half fill the upper Gharah with successive layers of charcoal. In the middle Gharah similarly put some layers of gravel, and in the third some fine sand. Remember that all of these should be half filled. Place some vessel to collect water below the third Gharah. Plug the hole in the bottom of each gharah with some cotton or a piece of sponge. Pour water for filtration in the upper-most Gharah. After a short time you will notice water flowing from the upper Gharah into the second and then into the third. Then water from the third Gharah will trickle and collect in the vessel below. This water is absolutely fit for all domestic purposes.

N. B. The teacher here should explain the principle on which it works.

Remember that this filter is quite easy to make and is of little cost and quite easy to manage.

The charcoal, the gravel and the sand should be changed frequently and the Gharas in use should also be thoroughly cleaned and put in the sun for some time.

It is not necessary that the Gharas should be glazed.

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